DOCUMENT RESUME

ED 176 980 SE 028 904

AUTHOR	Hofman, Helenmarie H.; Ricker, Kenneth S.
TITLE	Sourcebook: Science Education and the Physically Handicapped.
INSTITUTION	National Science Teachers Association, Washington, D.C.
PUB DATE	79
NOTE	270p.; Not available in hard copy due to copyright restrictions
AVAILABLE FROM	National Science Teachers Association, 1742 Connecticut Ave., N.W., Washington, D.C. 20009 (Stock No. 471-14760; $6.00)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Elementary Secondary Education; *Handicapped; *Handicapped Students; *Mainstreaming; *Physically Handicapped; Science Courses; Science Education; *Science Facilities; Science Instruction; Science Materials; Science Programs; Science Teachers; Teacher Characteristics; Teacher Education; Teacher Role; Teaching Methods
IDENTIFIERS	*National Science Teachers Association

ABSTRACT

Addressed is the increased need for information on science education and the physically handicapped following enactment of the Education of the Handicapped Act. The document is divided into ten sections including: (1) Science Education and the Handicapped; (2) Science for Everyone (mainstreaming); (3) Preparing Teachers to Work with the Handicapped; (4) Resources for Teachers/Schools; (5) Science and the Auditory Handicapped; (6) Science and the Orthopedic Handicapped; (7) Science and the Visually Handicapped; (8) Extending the Science Program Beyond the School; (9) Handicapped and Careers in Science; and (10) Implications for the Future. (RE)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED176980

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Helenmarie Hofman
NSTA

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SOURCEBOOK

Science Education and the Physically Handicapped

HELENMARIE H. HOFMAN, Ph.D.
Associate Director
Project for an Energy-Enriched Curriculum
National Science Teachers Association
Washington, D.C.

KENNETH S. RICKER, Ed.D.
Associate Professor
Department of Science Education
University of Georgia
Athens, Georgia

NATIONAL SCIENCE TEACHERS ASSOCIATION 1979/WASHINGTON, D.C.

SE 028 904

Designed by Joseph Jacobs
Copyright 1979 by the
National Science Teachers Association
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009
Stock No. 471-14760
Price $6.00

Preface

A handicapped person functions at his/her optimum level in an environment and lifestyle as close to normal as possible. Science is a vital part of that environment and lifestyle. Therefore, the National Science Foundation began funding projects designed to expand the participation in scientific careers of physically handicapped individuals with aptitude and interest in science.

In 1977 the National Science Teachers Association was awarded such a grant to hold the first working conference on Science Education for Physically Handicapped Students. The conference held April 3-5, 1978 provided 1) an assessment of the state of the art; 2) position statement; 3) recommendations to federal, state, and local agencies, institutions, and organizations.

The integration of physically handicapped students into science classes, K-12, will be the result of the efforts of the handicapped students, their parents and teachers, administrators, teacher educators, counselors, scientists and the interactions of these various groups.

With the enactment of Public Law 94-142, Education of the Handicapped Act, and the above conference, the number of requests for information on Science Education and the Physically Handicapped skyrocketed. The articles and papers presented address many of the requests with a variety of viewpoints and some solutions. Included are articles which appeared in *The Science Teacher* and *Science and Children*, NSTA, after 1975; *Access*, American Association for the Advancement of Science, 1977; Papers from *What Research Says to the Science Teacher*, Vol. II, NSTA; *Science Education for Handicapped Students, Proceedings*, NSTA.

The articles and papers have been divided into ten sections: **Science Education and the Handicapped,** an overview of science education for the handicapped including the conference results; **Science for Everyone,** implications for mainstreaming handicapped students into science classes; **Preparing Teachers to Work with the Handicapped,** teacher preparation programs which include training in science for the Handicapped; **Resources for**

Teacher/Schools, bibliographies and lists of appropriate agencies, organizations, associations, and journals; **Science and the Auditory Handicapped,** science for the deaf; **Science and the Orthopedic Handicapped**, science and support systems for the orthopedic handicapped; **Science and the Visually Handicapped,** history, programs and techniques for science for the blind; **Extending the Science Program Beyond the School,** variety of ways that science education is extended beyond the school walls; **The Handicapped and Careers in Science and Related Fields,** insight into what it means for a handicapped person to seek a career in science; **Science Education and the Handicapped, Implications for the Future,** an interpretation of the findings.

We extend our gratitude to the staff of the National Science Teachers Association and to the Science Education Department of the University of Georgia; to Marily DeWall, Janet White, and Delores Mason for their assistance on the Conference Proceedings Papers; to Martha Redden and the Staff of Project on the Handicapped in Science, American Association for the Advancement of Science; Ben Thompson, Science Education Department, University of Wisconsin-Eau Claire.

The 800,000 physically handicapped students in the United States now have the right to the least restrictive, most appropriate education. This education, as authorized by Congress, includes the right to assistance in obtaining a science education and the pursuit of careers in science or related areas. The ultimate goal is to provide quality science education for physically handicapped students.

Helenmarie Hofman
Kenneth S. Ricker

Contents

1

Science Education and the Handicapped

D. Brown	10	Introduction
Hm. Hofman	15	Working Conference on Science Education for Handicapped Students: A Position Statement The State of the Art Recommendations

2

Science for Everyone

	28	Introduction
L. Molloy	29	Law and the Handicapped
M. Redden S. Malcolm	32	A Move Toward the Mainstream
V. Proscia et al	35	A Challenge to Teachers from Handicapped Students
H. Hoffman	39	The Price of Being Born Disabled
N. Sharpless G. Vermeij J. Gavin	42	Achievement in Science

3

Preparing Teachers to Work With the Handicapped

	50	Introduction
D. McCurdy	51	Model for Preparing Teachers in Science for Handicapped Students
S. Johnston	66	Science for a Partially Sighted Junior High Child
G. Stefanich	73	Accepting the Handicapped
B. Berhow	80	Adapting Curricula for Handicapped Kindergarten Children
D. Hadary	87	Laboratory Science and Art for Blind and Deaf Children
R. Schnur C. Berger	94	Benefits from Science Education for the Handicapped
D. Swazuk	99	Mainstreaming Physically Handicapped Students

4

Resources for Teachers/Schools

106 Introduction
107 Bibliography:
  General Science
  Auditory Handicapped
  Science and the Orthopedic Handicapped
  Science and the Visually Handicapped
  Extending the Science Program Beyond the School
117 Organizations and Agencies
121 Professional Organizations (Education)
123 Federal Projects
127 Professional Journals:
  Science
  Physically Handicapped

5

Science and the Auditory Handicapped

130 Introduction
D. Brown 131 Teaching Science to the Hearing Impaired: Literature Review
H. Lang 140 Hearing-Impaired Physics Students and Implications for Teachers
F. Collea 148 Science in Sounds
H. Vlug 150 Science Education for the Deaf
R. Menchel 157 A lack of Science Education for the Deaf at the Elementary Level

6

Science and the Orthopedic Handicapped

162 Introduction
J. Hoyt 163 Adapting Science to the Disabled Learner

N. Thornburg 170 Science Education for the Physically Handicapped Student: Support Model
T. Post, H. Humphreys, M. Pearson 175 Laboratory-Based Mathematics and Science for the Handicapped Child
J. Windbigler 179 Computer Assistance for Physically Handicapped Students

7

Science and the Visually Handicapped

188 Introduction
F. Franks 189 The Tactile Modality in Adapting and Developing Science Materials
H. Thier 200 Fostering Observations in a Science Program for the Young Blind Student
E. Gough 206 Common Sense and Sensitivity in Teaching the Blind
P. Francoeur, B. Eilam 210 Teaching the Mammalian Heart to the Visually Handicapped

8

Extending the Science Program Beyond the School

220 Introduction
C. Fenn, D. Hamilton 221 Science Education in a Woodland Setting —A Program for the Handicapped
E. Keller, H. Keller 226 Marine Science Field Experiences with Handicapped Pre-College Students
D. Schatz, H. Overman 237 The Role of the Science Museum in Science Education of the Handicapped
K. Littman, D. Baron 242 The Environmental Approach to Recreation Services

9

The Handicapped and Careers in Science and Related Fields

	246	Introduction
B. Mendius	247	Science Education and Careers: Personal Views from Wheelchair Level
J. Dodd	251	An Intervention Program for Occupational Stereotyping by Deaf Students
C. Loperena	257	A Visually Handicapped Student Prepares for an Education Career
C. Fostnot	260	The Educator's Perspective of a Handicapped Student Teacher
R. Rehwoldt J. Samoff	263	Developing Science Education Programs for the Handicapped
H. Fawber et al	266	Attracting Handicapped Students to College Careers in Science
N. Berger	272	Science Career Information for Physically Handicapped Individuals

10

Science Education and the Handicapped: Implications for the Future

K. Ricker	277	Science Education and the Handicapped: Implications for the Future

1

Science Education and the Handicapped

1

Science Education and the Handicapped

Introduction

Dean R. Brown

Department of Education,
Colorado State University,
Fort Collins, Colorado

If you can look into the seeds of time and say which grain will grow and which will not—then speak ye to me.

—Macbeth

Who among us has the wisdom to predict which students will succeed and which will not? Are careers in science possible for the physically handicapped? Does a physically handicapped student learn differently from his or her peers? What teaching strategies, materials, and equipment will help the deaf, blind, or crippled students in our classes?

Handicapped Education: An Overview

Until the early 1900s, the handicapped were eliminated, ignored, made to work as indentured servents, or put into institutions. (8) Gearheart and Weishahn describe how, with the advent of public schools at the beginning of the 20th century, special classes for disabled youth were often utilized. Although special classes may have been useful to some students, the idea was misused and overused.

Walsh notes that the exclusion of handicapped youth from public schools resulted in inferior education for them; there is strong evidence that this is particularly true in science education. A survey conducted by the American Association for the Advancement of Science (AAAS) Project on the Handicapped in Science beginning in 1975 and also by the Science for the Handicapped Association in 1976 confirmed that the majority of handicapped students in private and public schools simply *have not* been exposed to science teaching. (10)

With the advent of Public Law 94-142, The Education for All Handicapped Children Act of 1975, and Section 504 of the Rehabilitation Act of 1973, exceptional children are guaranteed the right to receive high quality education in the "least restrictive setting." This legislation requires that students be placed in regular classrooms, mainstreamed for an optimal period of time each day, or placed in "the most appropriate situation for each individual."

Who Are the Physically Handicapped Youth?

Based on 1978 population data, several government agencies estimate that there are between six to nine million youth between ages 5 and 18 with some type(s) of handicapping conditions. (8)

. . . there are between six to nine million youth between ages 5 and 18 with some type(s) of handicapping conditions.

Approximately 0.6 to 0.8 percent of the school population (or 330,000 to 440,000 students) could be identified as having enough hearing loss, to be classified as *hearing impaired.* For the purposes of this paper, "hearing impaired" will be used to include the entire range of auditory impairments, including both deaf children as well as those with a mild loss.

Approximately 0.1 percent (or 55,000 students) could be classified as having *visual impairment* severe enough to require special educational services. As with terminology used in other areas of handicapping, there is much confusion in the words and concepts relating to persons with visual problems. (4) Barraga defines a visually handicapped child as one whose impairment interferes with optimal learning achievement, unless adaptations are made in the methods of presenting learning experiences, the nature of the materials used, or in the learning environment. (2) The terms "visually impaired" will be used to include the entire range of visual problems, including the totally blind child as well as the one with a mild visual loss.

Orthopedically impaired youth represent the most diverse and heterogeneous group of the physically handicapped. This group includes, for example, those with: cerebral palsy, muscular dystrophy, poliomyelitis, arthritis, osteomyelitis, congenital heart defects, clubbed hands and feet, absence of arms or legs, hemophilia, asthma, diabetes, allergies, epilepsy, and spina bifida. Approximately 0.5 percent (or 275,000 school-age youth) could be considered orthopedically impaired.

A Matter of Attitudes

Handicapped persons have often mistakenly been thought mentally deficient. Obviously, with such a prevailing social attitude, it has been exceedingly difficult for many physically handicapped individuals to even consider becoming scientists.

Handicapped persons have often mistakenly been thought mentally deficient. Obviously, with such a prevailing social attitude, it has been exceedingly difficult for many physically handicapped individuals to even consider becoming scientists.

James Gashel, discussing career barriers and discrimination against the handicapped, reveals that in ancient times disease and disability were ascribed to bodily possession of evil spirits, and disabled persons were often destroyed. (7) In Ancient Rome, drowning of defective children was sanctioned; baskets were even sold in the marketplace for this purpose. Any such children who survived were sold into slavery. Gashel, himself a blind scientist, further adds that "although we have advanced far beyond the ancient customs, our progress is definitely not complete in the truest sense. We are still yesterday's victims." When one stops to think about it, most idioms which refer to blindness and other handicaps carry with them suggestions of inferiority, incompetence, and stupidity ("blind choice," "blind stupor").

Instruction of the Hearing Impaired

What are some of the major obstacles faced by the hearing impaired? What does research say about strategies for teaching science to such handicapped youth? Up to the present time, there is a dearth of research on how hearing impaired students actually "learn" science.

Julia Davis reports that one of the major problems of the hearing impaired is language development. (5) As he or she matures, the hearing impaired child demonstrates an ever-increasing gap in vocabulary growth, concept formation, and ability to comprehend and produce complex sentences. Because language, speech, writing and reading pose such major problems for these youth, content areas such as science and mathematics receive low priority. Donald Moores suggests that class time designated for academic subjects is often devoted entirely to speech and language remediation. Since most teachers of the hearing impaired have not been trained in subject matter (just as most science teachers have not been trained in special education), the tendency to sacrifice content is increased. (9)

Instruction of the Visually Impaired in Science

Although there have been residential schools for the blind in the United States since 1832, many visually impaired youth have been integrated into regular classes since the early 1900s. Much credit for the early and continued efforts of educating the visually handicapped can be given to the American Printing House for the Blind (APH), established in 1858. The APH has produced, among other educational items, braille and talking book, large-type books, tapes, and tactile models for science and other subject areas.

The most significant changes needed for teaching visually impaired youth are in the adaptation of educational materials and equipment. These young people do not necessarily require a special curriculum, but materials and equipment must be adapted. Since approximately 80 percent of all school-aged visually impaired youth have some usable (residual) vision, Barraga feels it is of extreme importance to develop maximum visual perception ability in these students. (2) This is significant, according to Faye, because the more a child uses his/her vision, the more efficiently will s/he be able to function visually. (14) This idea is also held by Barraga, who suggests that the visual sense provides a greater quantity and a more refined quality of information in a shorter period of time than does any other sense, and therefore is the mediator between *all* other sensory information. (3) Barraga's studies show that when there is sufficient light to provide contrast between objects or to permit motion to be seen, there is potential for the child to use this visual information in meaningful ways. (2)

Published literature on techniques of teaching science to the visually handicapped dates back at least to the 1920s, but research studies are few, expecially for secondary-age students.

Instruction of the Orthopedically Impaired

There is a total lack of empirical research on how to teach science to the orthopedically impaired. This situation may exist because of the extreme heterogeneity of the conditions of this group of students. Technology has been devised, in many cases, for one single individual. Another problem is that of "finding" orthopedically handicapped youth. The AAAS committee of the Office of Opportunities in Science states that "many orthopedically handicapped children are in hospital schools where there seems to be no records of the academic program available and many are in schools for multiply handicapped children where the bright ones are lost amongst all the others." (1)

Summary

It is evident throughout this research that physically handicapped children can learn to understand science concepts and can develop higher levels of reasoning skills, afforded appropriate opportunity. They need direct, experiential, sensory experiences in science. Investigators repeatedly express the necessity of "doing science" by hands-on, inquiry-based, real-life experiences. Modifying existing curricula, strategies of instruction, and equipment, aided by technology, can give the handicapped youngster direct access to science, so that each individual can investigate science in a manner best suited to his or her individual style of learning.

References

1. AAAS Committee of Office of Opportunities in Science. "Science Education for Handicapped Youth." A background paper for meeting of OOS, Washington, D.C. March 1978.

2. Barraga, Natalie C. *Visual Handicaps and Learning: A Developmental Approach.* Wadsworth Publishing Co., Inc., Belmont, Calif. 1976.

3. Barraga, Natalie C. "Utilization of Sensory-Perceptual Abilities." In *The Visually Handicapped Child in School,* B. Lowenfeld, editor. John Day Co., New York, N.Y. 1973.

4. Brown, Dean R. "Science Instruction of the Visually Impaired: An Overview of Relevant Literature." (In press.)

5. Davis, Julia D., editor. *Our Forgotten Children: Hard of Hearing Pupils in the Schools.* Audio Visual Library Services, Minneapolis, Minn. 1977.

6. Faye, E. E. *The Low Vision Patient.* Grune and Stratton, New York, N.Y. 1970.

7. Gashel, James. "Discrimination Against the Handicapped." *Science, Technology, and the Handicapped.* AAAS Report No. 76-R-11. American Association for the Advancement of Science, Washington, D.C. 1976.

8. Gearheart, Bill R. and Mel W. Weishahn. *The Handicapped Child in the Regular Classroom.* The C. V. Mosby Co., St. Louis, Mo. 1976.

9. Moores, Donald F. *Educating the Deaf-Psychology, Principles, and Practices.* Houghton Mifflin Co., Boston, Mass. 1978.

10. Walsh, Efthalia. "The Handicapped and Science: Moving into the Mainstream." *Science* 196:1424-1426; June 1977.

Excerpt from: Brown, Dean. "Helping Handicapped Youngsters Learn Science by Doing." Rowe, Mary Budd. What Research Says to the Science Teacher, Vol. II, *National Science Teachers Association, 1979.*

Working Conference on Science Education for Handicapped Students

Position Statement

Helenmarie Hofman
National Science Teachers Association, Washington, D.C.

To assess the state of the art and develop recommendations for new directions in science education and careers in science for the physically handicapped students, the National Science Teachers Association (NSTA) convened a conference on Science Education for the Physically Handicapped Students. The conference was supported with a grant from the National Science Foundation (NSF). The ultimate objective of this conference was to affect the quality of science education for the physically handicapped student. Through working sessions the conference participants developed a position statement on science education for the physically handicapped student. (Refer to the Conference Proceedings for terms and participant list.)

■

Handicapped children have a right and a need to learn basic science content and skills.

Handicapped children have a right and a need to learn basic science content and skills. Evidence presented at the conference indicated that handicapped children are interested in and capable of learning science. Handicapped students have similar needs to those of non-handicapped students, therefore, it is necessary that equal education opportunities be offered to handicapped students.

Science courses should be an integral part of the education of all handicapped students from kindergarten through high school. Physically handicapped students should receive the same comprehensive exposure to the various fields of science as do non-handicapped students. Aspects of the science curriculum should include process, content, and career education with emphasis placed on early childhood and elementary programs as well as middle/junior high school and secondary school science programs. The teacher who teaches science to the physically handicapped must possess a strong comprehensive science background. Science teachers utilizing multi-sensory instructional techniques and laboratory-centered programs are able to effectively teach physically handicapped students in regular classes or special classes. The instructional strategies, techniques, and procedures found to be effective with the physically handicapped in science are those also found to be effective with the non-handicapped student. A great need exists for the dissemination of educational information about science materials, teaching aids, techniques, conferences, workshops, etc., to both the regular and special education teachers who teach science to the handicapped students.

Although many of the conference recommendations are somewhat costly, failure to meet these obligations will most probably be more costly in terms of the loss of the physically handicapped individuals' particular contributions to science and/or society. The societal loss will be professional, human, and economic. The anticipation of this loss provides the necessary rationale for following through on these recommendations.

State of the Art

The way to begin eliminating obstacles to the success of physically handicapped students in science education is to identify the specific problems. Knowledge of what exists in the field is essential. Based on the expertise, evidence, and experience presented by the conference participants, an overview of the state of the art for science education for physically handicapped students is presented here.

■

Conceptual and practical experiences assist all students in preparing for life. If educators will help the handicapped student to understand, use, and appreciate science, then these students may be more able to consider science or related fields as career possibilities.

Conceptual and practical experiences assist all students in preparing for life. If educators will help the handicapped student to understand, use, and appreciate science, then these students may be more able to consider science or related fields as career possibilities. Science is a vehicle for the development of learning skills in children. The study of science helps meet the psychomotor, psychological, and social skill development needs of both the handicapped and non-handicapped students.

In the sections on science education, careers, teacher education, materials, and evaluation/assessment present positive and negative practices are listed. (Conference, April 1978)

Science Education

Present positive practices:

- A current trend exists to involve handicapped and non-handicapped children in science experiences at an early point in their schooling.

- Individualization in curriculum planning—specific to the student's needs—helps prepare for the ongoing implementation of Education of the Handicapped Act, PL 94-142.

- Placing handicapped students in the most appropriate, least restrictive educational environment is mandated by PL 94-142. This includes science education.

- The trend to remove major architectural, communicative and attitudinal barriers in the schools facilitates learning in science as well as other areas by physically handicapped students.

Present negative practices:

- Science is not considered an important component of the curriculum for physically handicapped students.

- Physically handicapped students are not receiving comprehensive or regular exposure to sciences at any educational level.

- Present programs, facilities, and instructional strategies have not been adapted to meet the needs of the physically handicapped students in both special groups and mainstreamed science courses.

- Teachers are not always aware of and sensitive to the unique needs of the physically handicapped student.

- Teachers tend to limit themselves to visual or auditory strategies of instruction which may penalize some physically handicapped students.

- Presently, there exist negative feelings about mainstreaming the physically handicapped student that stem from a number of stereotypes, e.g., the stereotype that physically handicapped are also mentally handicapped.

- Many physically handicapped students are being barred from science courses, especially those courses that include laboratory experience, by physical barriers, teachers with negative or fearful opinions, overly cautious counselors, apprehensive parents, etc.

- PL 94-142 is often abused by mainstreaming handicapped students into inappropriate programs.

- When physically handicapped students are placed in regular science classrooms, the teacher generally has not been adequately prepared for the placement of these students, and has not been provided with the insight, special materials, skills, and/or techniques to effectively help the physically handicapped student learn science.

Careers

Present positive practices:

- A recent trend addresses the need for opening career possibilities, through presenting role models and identifying educational prerequisites to science or science related careers for handicapped students.

Present negative practices:

- Generally, science teachers are unfamiliar with the various career opportunities available in science and related fields for the physically handicapped students.

- There is no central information dissemination system, or source, serving as a resource for persons interested in career opportunities in science for the physically handicapped.

- While schools are becoming more accessible to handicapped students, most schools have not and are not currently hiring handicapped teachers for regular classes.

Teacher Education

Present positive practices:

- There are teacher education programs to prepare teachers for integrating the physically handicapped into regular science classrooms; however, these programs are limited to the efforts of a few individuals.

- Some teachers who have expertise with a particular disability group are beginning to share findings with other teachers.

Present negative practices:

- The attitude of science instructors, career counselors, and employers toward handicapped students is often neither encouraging nor appropriate.

- Little agreement has been reached as to what new skills and knowledge science teachers should possess to be competent in meeting the learning needs of handicapped students who enter regular classrooms.

- Many science teachers (especially elementary level) do not have enough knowledge of science education to make appropriate adaptations for special students; *or* they do not have enough familiarity with the facilitative mechanisms of the various disabilities of handicapped students to understand what adaptations are necessary for an optimal learning environment.

- Most pre-service teachers, in-service teachers, and para-professional science education programs have not had to consider the needs of the handicapped.

- Many teachers and counselors have inaccurate expectations of handicapped students which often result in poor student performance.

- Some teachers are over-sympathetic toward their handicapped students, this does not allow the handicapped students equal opportunity for academic success and/or failure.

Materials

Present positive practices:

- Curriculum development efforts have demonstrated that physically handicapped students can and, indeed, do succeed in science classes at the elementary, secondary and post-secondary levels, often with minimum equipment adaption.

- Major financial support for materials is not necessary to teach many science concepts to the handicapped students; however, creativity is needed. Science with everyday things (i.e., tin cans, rubber bands, paper clips, etc.) can be invaluable learning experiences, particularly at the elementary level.

- The use of the hands-on approach for a portion of class time in science, rather than only lecture and demonstration makes the knowledge more accessible, meaningful and more appealing to handicapped and non-handicapped students.

- The handicapped student can be a valuable human resource in the classroom with respect to his/her handicap (if and *only* if it is a comfortable situation for students).

- The use of partners (mutual choice) for some handicapped students has proven to be quite helpful in the science classroom laboratory.

- The multi-sensory approach is being used by some science teachers. This practice in the mainstreamed classroom can be very successful. It allows the visually, auditorially or the orthopedically handicapped students as well as the non-handicapped students to expand their science experiences.

Present negative practices:

- At all educational levels there is no current systematic way in which knowledge, resources, materials, etc., on teaching science to the handicapped can reach the classroom teacher on a regular basis.

- There is an apparent lack of materials and/or adaptations in science for the handicapped at various levels and in various science disciplines.

- Most teachers do not have time to devise creative adaptations and materials for science education for handicapped students.

Evaluation/Assessment

Present positive practices:

- The research on special programs in science education developed for a particular handicapped group in some model programs is commendable.

Present negative practices:

- Two recent nationwide surveys indicate that the major percentage of handicapped students are not receiving a quality education in science. A study done by Dr. Benjamin Thompson, University of Wisconsin-Eau Claire, 1976, revealed that state and/or other agencies have virtually no available information relative to science and the handicapped. The American Association for the Advancement of Science "Project for the Handicapped through Science" survey, directed by Dr. Martha Redden Ross, 1976, indicated that handicapped students receive little science instruction and what they do receive is not academically adequate to allow them to pursue science, science education, or science related fields as possible careers.

- There is no clearinghouse to provide teachers with information about science education materials, resources, etc. concerning science education for the physically handicapped student.

- There are a few definitive studies on how various handicapping conditions themselves influence teaching methods, materials, and activities used to teach science.

- There are no definitive studies detailing which of the programs and strategies currently available are most appropriate to the learning problems presented by the various handicapping conditions.

- Many of the programs, materials and learning activities developed to enable physically handicapped individuals to participate in science education have been designed for specific individuals or for groups of individuals with a similar handicapping.

Recommendations

The recommendations that emerged from the conference address concerns about current and future problems in providing quality science education for physically handicapped students.

Career Concerns

Handicapped students should have equal opportunities to pursue science related careers.

- Careers in science should be included among areas of career exploration and skill development for handicapped students; i.e., science should be an integral part of career awareness, exploration, and vocational preparation programs.

- Appropriate rehabilitation agencies personnel should be made aware and provide for many handicapped persons who need long-term educational preparation rather than short term preparation for semi-professional or semi-skilled and unskilled positions.

- Counseling and guidance training programs should be encouraged to include components pertaining to employment opportunities for the handicapped in various areas of science in their pre-service and in-service curricula.

- Projects which encourage the preparation and dissemination of information concerning career decision-making for handicapped students should be supported. This information should include role models, career sketches, and further resource contacts, and should be disseminated to elementary and secondary schools.

- The skills, experiences, and abilities of successful and established physically handicapped scientists and science educators should be fully utilized in developing, implementing, and encouraging the science education and employment of the physically handicapped.

- Science and science education associations should assist science oriented employers in becoming knowledgeable about the physically handicapped person's potential.

- Where possible and desirable, physically handicapped students should have a work-study experience in science.

- A network for the dissemination of career awareness, information and opportunities should be developed to inform science teachers, career counselors, physically handicapped and non-handicapped students of possible employment opportunities in science or science-related professions.

- Science career awareness, information, and opportunities for physically handicapped and non-handicapped students, i.e., career education, should be a part of the regular science instruction process.

Teacher Education

Pre-service teacher education programs should prepare prospective classroom personnel to teach science to handicapped students; and in-service programs should provide school personnel access to current information on teaching science to handicapped students.

- Education of the handicapped should permeate the whole teacher and counselor program. Special emphasis should be placed on increasing sensitivity to and awareness of the unique needs of the physically handicapped student as well as the needs of students with other special learning needs in science classes, while emphasizing the similarities to non-handicapped students.

- The training of special education teachers of physically handicapped students should include specific science instructional methods and curriculum materials that have proven to be successful.

- Teacher education programs should provide pre-service teachers with opportunities to work with physically handicapped students and to observe these students learning science in regular and special science classes conducted by effective science teachers wherever possible.

- Pre-service teachers, in-service teachers, and para-professionals should be trained in preparing Individualized Education Plans (IEP).

- Funds for special education teachers should be provided to permit them to attend training workshops and institutes on teaching science to the physically handicapped.

- Funds should be provided to facilitate the training of teachers in the modification of instructional strategies, materials, and equipment to meet the needs of the physically handicapped student in science courses.

- Teachers should have access to guidelines and principles for the adaptation of existing science programs/materials (i.e., in-service) and support of special resources and personnel.

- In-service teacher education programs should be provided for school administrators and counselors by professionals who have taught science to physically handicapped students in regular and/or special science classrooms.

Methods

Methods used in teaching science to physically handicapped students should provide opportunities for them to learn how to be independent learners and how to interact with non-handicapped persons.

- The science classroom environment should be as natural as possible.

- In helping the physically handicapped student solve problems, the teacher should limit their assistance so that the physically handicapped student has a basis for independent action to be transferred and utilized in the "real" world.

- Science teachers should encourage physically handicapped students to pursue independence in learning and augment that independence with strategies such as peer teaching

- Non-handicapped students and physically handicapped students should work together when possible using scientific problem-solving to invent techniques and devices to assist one another in learning science.

- Science courses for non-handicapped and handicapped students should include as much hands-on activity as appropriate.

- Science educators should urge physically handicapped students to participate in science fairs and other science competitions sponsored by such organizations as the Junior Academy of Sciences.

Materials/Programs

Special consideration should be given to the identification and development of instructional materials/programs that will help eliminate the barriers to the study of science for physically handicapped students.

- Funding agencies should give special preference to funding science programs which include the physically handicapped at the elementary, middle school and secondary levels.

- Curriculum development projects which provide for the physically handicapped students in science should be undertaken.

- In addition, in curriculum development, emphasis should also be placed on the adaptation of existing curricula as well as on developing new curricula for the physically handicapped.

- It should be required in the development of new curricular materials that attention be paid to illustrations in pictures and text. Such materials should include the physically handicapped as role models, both as students and as scientists in scientific courses.

- Funding should be made available for all related services (i.e., braillers, recorders, computers, group hearing aids, interpreters, etc.) to enable the physically handicapped student to participate in the normal activities of science education.

- Specialized materials such as captioned films, or materials developed by organizations like the American Printing House for the Blind must be made available to the regular classroom teacher of mainstreamed physically handicapped students.

- Parent education is needed to inform parents about materials and instructional aids and services that are available to facilitate the science education of their physically handicapped child.

Dissemination

In order for classroom teachers and counselors to plan and implement desirable science programs for physically handicapped students it is essential that they have on-going access to current and relevant information.

- The curriculum materials now available for teaching science to physically handicapped students need to be disseminated in a variety of ways.

- The development and dissemination of a newsletter concerning physically handicapped students in science education would help inform teachers and other physically handicapped students who may wish to pursue science.

- Publications, conferences or workshops devoted especially to science education for the physically handicapped should be "announced" in journals widely read by regular classroom teachers.

- Professional education journals should have regular features on science education for the physically handicapped student.

- Science Education for the Handicapped Conference Proceedings and position paper should be announced through educational journals and newsletters.

- A central clearinghouse should be developed which would provide resources in the following areas for the science education of all handicapped persons:

  a. Career opportunities and career education materials

  b. Teacher training

  c. Curriculum development

  d. Personal aids to assist learning

  e. Science education for handicapped students

Such a clearing-house would make these resources available for widespread distribution.

- Educational Resource Information Center/Science Math and Environmental Education Clearinghouse should receive information such as the following:

  a. The proceedings and papers produced during this conference and other conferences on related topics.

b. Articles and papers relevant to science education and physically handicapped students.

c. ERIC/SMEAC should search for and encourage the submission of articles and papers relevant to science education and the handicapped student.

ERIC/SMEAC information must be made available at little or no cost to science teachers. One way to do this would be to develop a hotline phone number available free to classroom teachers at all levels for gaining access to the ERIC/SMEAC system; and to advertise this service in professional journals.

- Science teachers must have easy access to the holdings of the Bureau for the Education of the Handicapped clearinghouses for materials for the handicapped such as the National Clearinghouse for Educational Media and Materials for the Handicapped.

- Professional educational conventions, both national and regional, that are related to science education should encourage and recruit displays and presentations by people who have been involved in science education for the physically handicapped student. All such conventions should be barrier-free.

Evaluation/Assessment

In the absence of a body of empirical knowledge on teaching science to handicapped students, systematic efforts to gather, organize, synthesize and disseminate this knowledge should be conducted.

- Funding in science education for physically handicapped students should be increased to include curriculum development, research, evaluation and dissemination.

- Agencies responsible for research in education should be encouraged to do more empirical research on science education for the physically handicapped.

- Research should be conducted on the specific instructional strategies and techniques, and instructional equipment that facilitate learning for the physically handicapped.

Educational Organizations and Agencies

Each professional education organization and agency should be actively concerned with the rights and needs of physically handicapped students to be taught science in an appropriate classroom setting.

- Each science education organization/agency should accept major program responsibilities toward planning and implementing science education for the physically handicapped.

- All boards of science education organizations should include representation of/for physically handicapped individuals as well as a science educator who had experience with physically handicapped students.

- Standing committees on science education for the physically handicapped student should be established within science education organizations/agencies at both national and regional levels.

- Presentations on handicapped students should be planned for all science education conferences. When appropriate, these presentations should be directed to the general assembly of science teachers, not to small groups.

- Professional science education and scientific organizations should develop strategies for informing legislators and agencies of the educational needs of the physically handicapped in science and should support the formation of a special commission to study the problems and recommend strategies.

- General guidelines should be established for facilitating safety in the laboratory. A handbook on recommended adaptations that science teachers can make to accomodate physically handicapped students in regular classrooms and laboratories should be published and periodically updated.

- Funding institutions should support summer science programs which include physically handicapped students.

- All television program sponsored or approved by educational organizations/agencies should include captions and/or interpretors.

- Appropriate science activities should be incorporated into programs of community organizations such as scouting groups, YMCA, YWCA, museums, parks, etc., which should actively seek participation of the physically handicapped.

2

Science for Everyone

2

Science for Everyone

Introduction

The movement to establish the right for handicapped students to receive a meaningful education in an appropriate educational environment has recently reached a climax. Several federal court decisions during the 1970's have been very instrumental in this achievement. During this same period of time federal legislation which recognized the needs of handicapped children was enacted. In November 1975 the Education of All Handicapped Children Act (PL 94-142) was passed. This Act consolidated much of the earlier legislation and also provided a means for implementing the legislation. PL 94-142 is often referred to as the Bill of Rights for Handicapped Children.

Another federal law, the Rehabilitation Act of 1973, has implication for the education and careers of handicapped persons. The regulations for Sections 503 and 504 of this Act are designed to eliminate discrimination against handicapped persons in educational programs and employment.

In this chapter federal legislation relating to the education of handicapped students in the least restrictive environment is reviewed. Some implications for mainstreaming handicapped students into science classes and the role of the American Association for the Advancement of Science is helping to achieve quality science for these handicapped students are discussed. Science teachers are presented with challenges from four physically handicapped scientists. The chapter closes with a discussion entitled "The Price of Being Born Disabled" and brief biographical sketches of three handicapped scientists.

Law and the Handicapped

Larry Molloy
Educational Facilities Laboratory, New York City

Eight million school-age children, roughly one out of ten in the United States, are handicapped. Collectively, such children comprise all persons between age five and 17 who are physically or mentally impaired to the point that they need help not required by "normal" youths. By universal agreement, a "handicapped" child has a speech, hearing, or vision problem, may be learning disabled, crippled, or mentally or emotionally disturbed. Gifted children and those disadvantaged by social or economic problems are not included. According to The Council for Exceptional Children, approximately three and a half million of these children are now enrolled in special education programs; three and a half million go to schools where they receive no special help, or reside in institutions; and one million remain at home receiving no special help.

. . . one out of ten in the United States are handicapped.

The Changing Mandate for Special Education

All over the United States, handicapped children and their parents are demanding an equal opportunity for an appropriate education. What exactly an appropriate education means for handicapped children is at issue but, in general, state legislatures and federal courts are ruling that public schools may no longer refuse services to any children despite their handicaps.[1] A major part of the controversy over handicapped children concerns those in special schools and state institutions far from their local school districts who are now seeking admission to homes and schools within their community. Court decisions in Wisconsin, Maryland, Pennsylvania, Louisiana, Utah, and the District of Columbia, indicate that with rare exceptions, public schools must provide appropriate services for all handicapped children who reside within the district's boundaries, or, as the student's advocate, the public school system must see that proper support services and aftercare are made available from local agencies. In short, the courts are setting guidelines for where, how, and with whom an appropriate education for handicapped children takes place.

Today, all 50 states have laws that provide some kind of educational services for handicapped children. Most of these laws do not yet mandate a comprehensive education for all categories of handicaps, but the trend is clearly aimed at mandatory universal enrollment of all handicapped children in all public services. Significantly, these laws require that the handicapped must be equally eligible for all services offered to the public under equal terms and conditions—including kindergarten, day care, transportation, recreation, and adult education if such services are offered to "normal" citizens.

---

[1] *Public Law 93-380, Part VI B, Education of the Handicapped states that "to the maximum extent appropriate handicapped children should be educated with children who are not handicapped and that special classes, separate schooling or other means of removal of handicapped children from the regular educational environment occurs only when the nature or severity of the handicap is such that education in regular class with the use of supplementary aids and services cannot be achieved satisfactorily."*

Age is another important factor in school planning for the handicapped. Most states mandate a free public education for handicapped children *ages 5 through 21*. However, seven states (Michigan, Washington, South Dakota, Maryland, Mississippi, Ohio, and Kansas) authorize diagnostic, remedial, and educational services at birth and West Virginia extends the mandate to age 23. It is, therefore, not uncommon for a handicapped student to remain within the public school system for 20 years. Public schools must begin to plan for a new student constituency who will be enrolled in public schools for as many as ten years longer than their nonhandicapped peers.

■

Public schools must begin to plan for a new student constituency . . .

In every mandate or state directive, the burden of implementation falls squarely on public schools. Every comprehensive state law mandating equality for the handicapped requires that public schools must shoulder the primary responsibility for educating all handicapped children, must actively solicit enrollment, and must emphasize individual diagnosis, evaluation, and program delivery—not classification by labels or group category.

In addition to state legislation, the judicial system is also firmly upholding the rights of the handicapped to equal treatment, equal education, and equal opportunity. Such rights include a free public education for all handicapped children regardless of the class or the severity of their handicap; an education appropriate to each child's individual needs, including toilet training and self-grooming as reasonable educational objectives; treatment and therapy in accordance with the disability; appropriate services within a reasonable period of time after application—usually within fifteen days; due process; and the right of the least restrictive alternative.

The Least Restrictive Alternative

For school planners, the least restrictive alternative is the most important of these rights because of its impact on the deployment of facilities and services for handicapped constituents. The term "least restrictive" is not included in the United States Constitution but, in a series of cases spanning many years, the Supreme Court has insisted that when a governing organization legitimately seeks to restrict a person's fundamental liberty, it must use the least restrictive alternative available. For schools, the least restrictive alternative is a principle that affirms any practice for the handicapped that is also provided for ordinary students but denies school officials the right to remove or restrict handicapped students without good reason and due process.

For example, many school districts frequently discharge their obligations to the handicapped either by providing tuition assistance for a private education, by transferring the student out of the state or district, or by constructing a special center in a remote corner of the district where all handicapped children are sent for learning and therapy. According to the least restrictive alternative concept, handicapped children should be sent to one of these environments only if their handicap is severe enough to necessitate complex services and only after access to a hearing with legal counsel.

> *. . . handicapped children should be placed where they can obtain the best education at the least distance away from mainstream society.*

The least restrictive alternative means that among all alternatives for placement within a general educational system, handicapped children should be placed where they can obtain the best education at the least distance away from mainstream society. Whenever handicapped children are sent to a restrictive environment, such placement should be aimed at their eventual integration into an appropriate public school.

The Trend Is Toward Home Schools

Misunderstanding the intent of court decisions, some school districts are constructing "all exceptional" centers where all handicapped children are sent for special treatment and training. Because of the courts, however, there is a visible trend away from these magnet centers for the handicapped. In fact, a growing number of lawsuits are challenging the legitimacy of remanding students to such special centers. The *Pennsylvania Association for Retarded Children* vs. *The Commonwealth of Pennsylvania* decision,[2] for example, clearly states that it is more desirable to educate handicapped children in a program most like that provided for the nonhandicapped. For many handicapped children, this means integration into their home school.

The impetus of court actions so far is clearly away from secluded environments exiled from the community, and toward less restrictive, mainstream facilities most like those provided normal children, that is, the least restrictive alternative.

Most of these decisions recognize that public schools alone cannot offer every service handicapped children may need, and no legislation or litigation has called for the abolishment of state institutions. The momentum of this new human rights campaign has altered the flow of students into institutions and special education centers. Disabled children are being sent home from the institutions and their parents are calling upon local schools to provide the same services as they provide to any child, and in doing so, to provide whatever remedial treatment is necessary.

---

[2] *For more information on the Pennsylvania decision, see* Right to Education: Anatomy of the Pennsylvania Case And Its Implications for Exceptional Children, *available from the Teachers College Bookstore, Columbia Teachers College, 1224 Amsterdam Ave., New York City 10027.*

Excerpt from Science and Children, *13:6, 7-10, March 1976*

A Move Toward the Mainstream

Martha Ross Redden
Project on the Handicapped in Science
Shirley Mahaley Malcom
Office of Opportunities in Science, American Association for the Advancement of Science, Washington, D.C.

The child was labeled as disabled, thus emphasizing his or her dissimilarity, when in fact the similarities to other children were always greater than educators realized.

Until recently most educators felt that the "special child" could receive better training when separated from "normal" peers. This attitude led to the creation of special education programs built around the idea of disability, rather than ability. The child was labeled as disabled, thus emphasizing his or her dissimilarity, when in fact the similarities to other children were always greater than educators realized.

This attitude of spotlighting the child's differences has met with severe criticism from many groups, forcing educators to reconsider their placement of the special child. The move toward mainstreaming has gained momentum. Whole school systems are doing away with special education practices of the past and placing handicapped children when possible, in the mainstream of the educational system.

What Does Mainstreaming Mean?

What does this mean to teachers of science? That they may have special children with various types of handicaps in their regular classes, and that they will have to include the handicapped child in regular class activities and set a wide range of competence goals for the class which can include the special child. Teachers will have to assess the ability of the child and consider realistically how the child's handicap does or does not affect his or her ability to do science. The teacher may have to locate or adapt science materials for the particular disability of the child. Because of the extra work involved in doing this, the teacher may be tempted to exclude the special child from the "hands-on" part of science. But a broad range of science experience, both theoretical and practical, is necessary to guide the handicapped child toward an understanding and an appreciation of science or even the possibility of choosing science as a career.

The American Association for the Advancement of Science (AAAS) Project on the Handicapped in Science made a preliminary survey in the fall of 1975 to find out how much science education handicapped students are actually receiving. With the results, AAAS could conclude that most handi-

It must be the teacher who provides the kind of science education that allows the handicapped child to live a fuller life and even to choose science as a career.

capped students, whether in special schools or public schools, receive little science; what they do learn is not adequate in quality to allow them to pursue science as a career. With few exceptions, there is little or no responsibility being taken at the state level for providing quality science education for non-retarded physically handicapped students. However, the state mandates on education are ultimately interpreted by the individual teacher whose commitment to quality education is evidenced in the classroom. It is the teacher in day-to-day contacts with students who can offer the tools and skills to overcome handicaps. It must be the teacher who provides the kind of science education that allows the handicapped child to live a fuller life and even to choose science as a career.

. . . students have a right to function in an optimum environment that is least restrictive to their personal development.

Mainstreaming is inevitable on a nationwide scale. Court rulings[1] and research findings which have established the "principle of normalization"[2] all point to the fact that students have a right to function in an optimum environment that is least restrictive to their personal development.

To provide a quality science education for the handicapped child while also addressing the needs of their non-handicapped peers, the teacher will need access to a wide variety of material and human resources.

The AAAS Project on the Handicapped in Science has people working to challenge and assist the science community to remove educational and occupational barriers for the handicapped, and one group of people is developing programs which can assist teachers in meeting the needs of handicapped students.

The AAAS Programs

This Project on the Handicapped in Science was initially directed toward the problems of the adult handicapped who face barriers and discrimination in employment. Basic to most barriers is the early training that handicapped children receive in elementary and secondary school. In elementary grades children are first introduced to the scientific method of problem solving and learn the vocabulary that allows understanding of scientific concepts. Without this background it is almost impossible to achieve success at the secondary level and beyond.

The AAAS programs will address two problems basic to the improvement of science education for the handicapped child: (1) the improvement of preservice and inservice teacher training in science to prepare teachers to include the handicapped child in mainstream situations; and (2) the preparation and dissemination of inventories of human and material resources.

---

[1] *See footnote 1, page 29.*

[2] *The "principle of normalization" states that the handicapped person functions at his/her optimum level in an environment and lifestyle that are as close to normal as possible.*

Mainstreaming will offer richer educational opportunities to handicapped students than they have had before, but it will not guarantee them improved science education. Teachers of science in the mainstream school settings must accept the challenge of involving the handicapped child as a contributing member of their regular classes.

SCIENCE and CHILDREN, *13:6, 14, March 1976*

A Challenge to Teachers from Handicapped Scientists

Statements from four members of American Association Advancement of Science: Proscia, Stearner, Keller, & Ballantyne

Vito Proscia

Vito Proscia is Vice President of Tele-Sensory Systems and on the board of trustees of the National Braille Press in Boston. He received his master's degree in electrical engineering at Columbia University and has completed two years of doctoral work in engineering.

After becoming blind at the age of 11, I received my elementary and secondary education at a residential school for the blind in New York City. While in high school, I discovered I had an inclination, interest, and adaptability toward science and mathematics. My interest in the sciences was further stimulated by a course offered in amateur radio electronics. After this, I realized that my goal was to pursue a technological or scientific career.

■

My interest in the sciences was further stimulated by a course offered in amateur radio electronics.

The residential school did not have proper staff or facilities for instruction to prepare its blind students for science education. Few basic courses were offered, and I was required to make up classes during my early college years. In defense of the school, I can honestly admit that at that time it was uncertain whether or not blind students could achieve in science as a profession.

I enrolled as a physics major at a local college. Because of my strong interest in electronics, my electives were in the school of engineering. No special instruction or special aids were provided while in college, but I was required to use readers and lab assistance in order to complete my education. Upon attainment of my bachelors degree, I applied for employment at a research laboratory associated with a well-known university in New York City. Most of the work was concerned with aerospace research. In the meantime, I was able to pursue my masters degree in electrical engineering.

After working many years in aerospace research activities, Massachusetts Institute of Technology appointed me as Director of its Sensory Aids Evaluation and Development Center, the purpose of which was to apply technology in advancing the needs of the blind.

My technological background, including my own personal handicap, provided me with the perspective to deal with these problems. My present position as vice president of a company inventing, manufacturing and distributing products for the handicapped has been the most satisfying of my career. I believe that a greater emphasis should be placed on science education with respect to the handicapped so that opportunity to enter scientific professions can be pursued by all.

Phyllis Stearner

Phyllis Stearner works in the Division of Biological and Medical Research at the Argonne National Laboratory in Illinois. Even though she has cerebral palsy, Dr. Stearner has been a research biologist for many years.

When I was young I learned about the bumblebee. This is an animal that, according to accepted aerodynamic principles, should not be able to fly. But the bumblebee knows nothing about such principles and may be seen winging its way among the flowers on a warm summer day. I would watch the bumblebee and other animals in my back yard with the greatest of interest when I was a child. I had all sorts of questions but no one to provide the answers.

My early years were completely devoid of any direct experience in science. I never learned that handicapped children, especially those with Cerebral Palsy, do not grow up to become scientists. Now, after almost 30 years as a scientist in radiobiology, I consider with amazement the series of improbable events that led to my obtaining a PhD from the University of Chicago and my career as a biologist. When I was a child I did not know what research and science was all about, so I went on my stubborn and determined way and eventually succeeded somewhat like the bumblebee.

■

My interests were always in science, most particularly biology and medicine. During my childhood, friends, and relatives provided me with books about scientists and their discoveries.

My interests were always in science, most particularly biology and medicine. During my childhood, friends, and relatives provided me with books about scientists and their discoveries. This provided background information, but since I had a single private tutor throughout elementary school there was no opportunity for more exposure to the great world of science. My somewhat overprotective father felt it was too hazardous for me to go to school with other children who in their enthusiastic play might harm me. It was with great financial sacrifice that he provided a tutor who instructed me for one hour a day. I did learn to learn independently, but the tutor covered only reading, writing, and arithmetic. I was prevented from the usual personal interaction with my peers. It was my mother who provided the greatest encouragement for education of all kinds. I had collections of catepillars in jars on the porch railing and especially enjoyed watching them crawl up my arm so I could observe them more closely. While my mother did not really share my enthusiasm for insects and snakes, she never objected to my activities and encouraged me to learn as much as possible about whatever interested me.

My access to science was only through books during the years of elementary school, so I was fascinated by laboratory experiences when they were finally available to me. I attended three different high schools: one for normal children (in a small town) and two even smaller ones for physically handicapped children. A high school chemistry course in which the students did a few experiments was the extent of my lab experience. The chemistry teacher was very good and I found my scientific interests heightened during this period. Since there was no biology course, I had to read more books in that subject, and I had never used a microscope by the time I entered junior college.

Society achieves the kind of excellence it values. Nothing would provide greater return to society, I believe, than increased emphasis on and appreciation for science in our elementary schools, with special attention to ways to help physically handicapped children learn. Elementary school teachers should be experienced and sensitive to the special needs of physically handicapped children and most important, they should have appreciation for their abilities rather than their disabilities.

E. C. Keller, Jr.

Dr. Keller is Professor of Biology at West Virginia University in Morgantown and a member of the Advisory Committee to the American Association for the Advancement of Science Project on the Handicapped in Science, was stricken with polio at the age of 17 and was left orthopedically handicapped. He was named Alumnus of the Year by the National Foundation in 1965. Dr. Keller, a former university administrator and former science materials reviewer for NSTA, has a breadth of knowledge in different science areas including biostatistics, genetics, ecology, and education. He has received numerous fellowships, contracts, and grants, including a series of National Science Foundation grants in pre-college training in science.

I have observed, over a period of time, that few of my undergraduate science students have been physically handicapped. Likewise, my fellow professors here and in other schools have noted a deficiency in representatives of the handicapped minority relative to the numbers of physically handicapped in the overall population. (President Ford recently stated that some 28 million Americans fall into this minority group out of a total population of 220 million, or 13 percent.) If the handicapped were proportionately represented in our college and university systems, then there should be larger numbers of handicapped in science at the undergraduate and graduate levels.

Recently, members of the American Association for the Advancement of Science Committee on the Handicapped in Science have attempted to locate their handicapped peers. We were unable to find, at first glance, handicapped scientists who had had their handicap since birth. One of our members was heard to say that perhaps it is because none exist. Undoubtedly, this statement is untrue, but my shock led me to hypothesize as to the reasons for the apparent lack of "handicapped from birth" scientists.

Why are "handicapped from birth" scientists so rare? Has society failed these individuals? Briefly, reflect on two of the ingredients in the making of a scientist: desire and interest that grow into ambition to be a scientist, and the educational opportunity to reach this goal.

Why are "handicapped from birth" scientists so rare? Has society failed these individuals? Briefly, reflect on two of the ingredients in the making of a scientist: desire and interest that grow into ambition to be a scientist, and the educational opportunity to reach this goal. The first of these ingredients is often missing because of the obvious lack of visible role models. How often do these children see a handicapped doctor or other science professional in real life or on television:

What about educational opportunity? Did these handicapped students receive the preschool training, the elementary school skills, or the secondary refinement and enrichment necessary for following a science program in college? Probably not, since a strong science education is usually not available in the segregated classes or residential schools in which physically disabled students have generally received their early education. Clearly, quality science education must be available to all. A call for equal education at all levels, regardless of the type of handicap, is in order. You, as a science teacher, must meet the challenge of providing the handicapped child with the opportunity for a good science education.

Donald L. Ballantyne

Donald L. Ballantyne is currently employed as a professor of Experimental Surgery at the New York University Medical Center. Dr. Ballantyne is capable of teaching surgery to medical students, but was not allowed to enter medical school because of his deafness. He received his PhD from Catholic University.

Because of my father's business, I was born in Peking and brought up in the Far East. Spending so much time in places with high rates of communicable diseases gave me a keen interest in preventive and curative medicine.

I never attended schools especially for the deaf, but rather attended with hearing children.

My school in China was arranged very differently than it would have been in the United States. I never attended schools especially for the deaf, but rather attended with hearing children. I had private tutoring daily for my speech and lip-reading.

My science training came mainly from well written textbooks that were excellent substitutes for teachers who were neither well versed nor interested much in science. I believe that a good textbook and a good tutor, combined, are an excellent source of information, especially to those with hearing impairments.

SCIENCE and CHILDREN, *13:16, 15-16, March 1976.*

The Price of Being Born Disabled

Herbert H. Hoffman
National Weather Service
Chicago, Illinois

When one is born with a disability severe enough that society shoves him into educational and social programs (which non-handicapped persons develop), one becomes separated from 'normal' persons. Thus, all through his school years he is forced to learn from other disabled students. Teachers that enter into special education programs do not have an opportunity to interact with the physically handicapped until they are hired by a school. Therefore, the lack of understanding of how to make the disabled students perform at the highest level possible allows teachers to design courses to fit the limitations of his physical handicap. This makes the student fall further and further behind his 'normal' peers. Since higher education and employment for the disabled are still hard to obtain, teachers will often let studies decline to a point that they think should be the level at which their physically handicapped students can perform. Parents of the severely disabled generally agree with the teachers for two basic reasons: 1) The lack of confidence that their child may someday be able to find employment and become a useful part of society. 2) The parent feels sorry for the child and does not want to see him study so hard when he could be enjoying the outdoors or doing his physical therapy which would enable him to do more for himself when grown.

■

. . . the lack of understanding of how to make the disabled students perform at the highest level possible allows teachers to design courses to fit the limitations of his physical handicap.

Most sociologists agree that children learn mainly from their parents and peers. Most parents of handicapped children do not give their child the encouragement that he needs to overcome his fear of not becoming useful. The teachers and his peers do not offer encouragement because they too are unable to see any successful handicapped people who graduated from their school. Perhaps this is why the handicapped persons who develop drive and won't take 'no' for an answer are the only ones that beat the system and go on to make something out of their lives. However, these persons are often labeled by teachers, parents, and rehabilitation specialists as 'special,' thus putting them above the other students. Most of the other students do not feel they will ever be 'special,' and, therefore, they are not encouraged by those few 'special' persons.

■

The teachers who are handicapped themselves make the greatest contribution to disabled students.

The teachers who are handicapped themselves make the greatest contribution to disabled students. If they are lucky enough to teach in a school that has both 'normal' and handicapped students, the contribution is even greater. These teachers can teach the handicapped students from their own experiences, and will often make the students work twice as hard as 'normal' teachers do for they know that if a handicapped child is ever going to get ahead in society, he will have to be twice as knowledgeable as a 'normal' child. The handicapped teacher will imprint on the minds of the 'normal' student that the disabled are the same as anyone else except that they are physically limited. When these students grow up and find employment, they will have more understanding toward the physically handicapped and will perhaps try to change the attitudes toward the disabled. In the long run, I feel it will be the attitudes of our society that will have to be changed if the physically handicapped are going to be able to live a life that is 'normal' and fruitful as possible. It should be remembered that the mind is the most important part of the body, and the physical part can be handled by a robot.

It might seem ironic that three teachers who had the most impact upon my career, as well as my life, were all handicapped. The first was an elementary school teacher in an all handicapped school who had the understanding that I could contribute more if I were allowed to type with my foot (which I did at home) in class. The other two handicapped teachers were a high school English and a high school Science teacher. My English teacher got polio rather late in life, and besides being very good (but very hard) as a teacher, she taught us that our physical limitations did not mean that we could not be useful instead of sitting at home and vegetating. She taught us how the power of letter writing could be used to obtain what we wanted out of life. Later this became the way I got the Division of Vocational Rehabilitation to finance my college education and it was also how I became employed. When she was asked to retire because her teaching was not what the school wanted, I received my first look at what society could do if they didn't like someone. This could not happen today—or could it? Since I was always interested in science, I guess I worked rather hard at it and even though I could not use my hands for lab experience, I watched my fellow students. Sometimes I was able to tell them how to conduct an experiment. My Science teacher, who was handicapped himself, understood this concept the best: it is more important for a scientist to know how and why an experiment is done than to physically go through the motions which a robot can do. This teacher also encouraged me to enter science fairs and spent many long hours with me going over the science papers I wrote. I became the first handicapped student to attend a city and state wide Science Fair—but not with the approval of the school principal. Since my speech defect made it hard for persons to understand me when it became time for me to explain my science project, I found a fellow student to talk for me. Many hours were spent training him about my project and what to say.

I became the first handicapped student to attend a city and state wide Science Fair—but not with the approval of the school principal.

I feel a new dawn is breaking for the handicapped with the implementation of Section 504 and of Public Law 94-142 regarding teaching of the disabled. The handicapped are no longer required to attend all handicapped schools, but can attend a school in their own district so they will be among 'normal' students from their own neighborhood (which will also improve their social outlets). This should solve some of the isolation problems that many disabled persons (including myself) faced. There is, however, a danger that the schools will not follow the intent of the law. For example, schools could make only a few classes barrier free and hire a few special education teachers who will develop programs especially for the handicapped. These programs will take the disabled out of the classroom, thereby increasing the isolation problem. If science teachers are allowed to substitute non-lab classes (which HEW allows if cause can be shown), lab sciences are likely to be eliminated because modifications will take the longest. Also, some science teachers and department administrators might not like the idea of having the severely handicapped students in their lab classes where physical limitations may prevent them from carrying out some experiments. It is up to the handicapped scientists to encourage teachers and handicapped students and to aid in the development of modified courses so that maximum education is possible. We should give our knowledge freely to those who want it and those who do not want it.

Once we educate the handicapped persons in science, we have to see to it that science will give them employment. We are asking society to pay for the education of the handicapped in science and we have to answer to them if the graduate is unable to find employment. We must be willing to act as role models and research persons keeping in mind that the disabled person might only have one chance at employment, for the disabled can't pump gas or wait on tables while they are waiting for the right job to come along. Because education has allowed them to know what it is like to be as independent as possible, severe depression will overcome the student if he has to return home where he is not useful. Suicide is often thought of, and depending on the individual's drive, can lead to a deadly end. Employment must follow education.

Achievement in Science

Nansie S. Sharpless
Research Biochemist, Albert Einstein College of Medicine, New York

"A veterinarian? Of course you can be a veterinarian," the doctor said, giving my parents a knowing wink. It was January in 1947. One month earlier a bout of meningitis had left me completely deaf. Now I was wondering what effect deafness would have on my career choices. At age 14 I hadn't exactly decided what I wanted to do. Like most girls in those days I supposed I'd work for awhile then maybe get married. Science and math were my best subjects and my parents had never discouraged my interest. My father was a biochemist and I had visited his laboratory and played with his rats. Then I had received a doctor kit at an appropriate age and my sister and I had converted a quarter of the basement into a hospital ward with rows of beds to care for our dolls and stuffed animals, all of which had suddenly become sick. A veterinarian would not have to talk to her patients, I reasoned. It would be a perfect career for a deaf person! It never occurred to me then that deafness might mean I couldn't finish high school and college and then earn my own living.

Years later, after I had done just that and had earned a doctorate, as it turned out not in veterinary medicine but in biochemistry instead, I learned that others had not been so certain. The social workers at Columbia University's Vanderbilt Clinic had told my parents that deafness would make it impossible for me to continue in a regular classroom. But, when my parents tried to enroll me in a school for the deaf, they found that my years of normal hearing had placed me far ahead of my deaf age peers who had to spend extra time learning to speak and to use language. My parents therefore decided that I should return to my regular ninth grade classes and they arranged for me to have instruction in lipreading once a week on Saturday morning.

My classmates, who lent me their notes and relayed assignments, and teachers, who wrote extra comments on my papers and on the blackboard, were especially helpful at this time.

My classmates, who lent me their notes and relayed assignments, and teachers, who wrote extra comments on my papers and on the blackboard, were especially helpful at this time. The major hurdle was learning to study. People who hear take it for granted the tremendous amount of information they get effortlessly by overhearing conversations around them. Suddenly deprived of this input, I had to learn to acquire the information by looking it up in a book. Often it felt as though I was reading half the library just to be sure that I did not miss the one point the teacher thought to be important.

■

. . . it was a medium sized college with a reputation for academic excellence but also because it was 500 miles away from home. The latter was important to me because I wanted a chance to develop independence.

In 1950 I entered Oberlin College. I chose Oberlin not only because it was a medium sized college with a reputation for academic excellence but also because it was 500 miles away from home. The latter was important to me because I wanted a chance to develop independence. No special arrangements were made for me, and I made no attempt to lipread the lectures. Usually I asked a classmate if I could copy her notes as she took them down, and I relied heavily on the textbooks. Later on, in graduate school, I found that I could lipread some of the lectures if the teacher's speech was clear, but notes of my classmates were still very helpful because it is impossible to write anything down while lipreading.

I did exercise some selection in the courses I took. To satisfy the fine arts requirement, I took studio drawing instead of music appreciation. To fulfill the language requirement, I took German, which was taught by reading, instead of French, which was taught conversationally. Science courses, because they required hands-on laboratory work were always more fun than the more abstract and unillustrated history or philosophy lectures.

■

I could tell by touch whether a centrifuge was operating properly. I was usually able to communicate with my co-workers by lipreading, although we occasionally resorted to pencil and paper.

I received a bachelor's degree in zoology and enrolled at Wayne State University in a master's degree program in medical technology. After graduation I worked as a research medical technologist for eleven years, during which time I authored and published several papers in immunochemistry and protein chemistry. I encountered few problems that could be related to deafness. I could tell by touch whether a centrifuge was operating properly. I was usually able to communicate with my co-workers by lipreading, although we occasionally resorted to pencil and paper. There was always someone else around who could answer the telephone. I eventually reached a position where I supervised the work of several technicians.

I encountered considerable opposition to the idea of a return to school. My friends and family exerted subtle pressures. There were dire predictions that I would not be able to find a job because I would be over-educated. I was warned that higher standards of excellence would be required of me, and there would be questions about my abilities to carry out the professional duties of a chemist. Nevertheless, I went ahead and eventually obtained a PhD in biochemistry with a distributed minor in chemistry and, after four years of post-doctoral training at Mayo Clinic in 1975 I joined the faculty at Albert Einstein College of Medicine to organize a monoamine assay laboratory for the Departments of Psychiatry and Neurology. I have special expertise in the analysis of neurotransmitter amines which are chemicals thought to play an important role in brain function. I am involved in several research projects designed to give insight into the nature of changes in neurotransmitter amine metabolism associated with various neurological and mental disorders as well as with normal fluctuations of mood and behavior. It is fascinating work and I have never regretted my decision to go for a doctorate.

Geerat Vermeij
Biology Professor, University of Maryland, College Park, Maryland

When I was in fifth grade, my teacher asked all the pupils in the class what they wished to do for a living. Only about a year earlier, I had become seriously interested in shells, and I therefore answered, "Conchologist."

"Would you spell that," requested the teacher.

I obliged, and nothing more was said about it. This performance became a yearly ritual. Beginning in seventh grade, my answer changed to "Malacologist," later to "Biologist." As far as I can remember, no one showed great surprise or concern at these answers; and if any attempts were made to dissuade me from this course or to encourage me to think about more practical things, these were feeble and directed at the wall.

My parents were perfectly content with my choice, and indeed encouraged me in every conceivable way. From my earliest years in Holland, they took my sighted brother and me into the countryside, and showed us flowers, birds, shells, pinecones, acorns, nettles, insects—everything. Several of my teachers in school reinforced this interest in natural history; not only did they often take their blind charges in the field, but there was also a fine collection of stuffed mammals and birds in the library, and there were trips to the Artis Zoo in Amsterdam, where we were permitted to handle living snakes and turtles.

■

From my earliest years in Holland, they took my sighted brother and me into the countryside, and showed us flowers, birds, shells, pinecones, acorns, nettles, insects—everything.

Immigration to the United States in 1955 brought with it a radical change not only in natural surroundings (from the flat polders and heaths of Holland to the wooded mountains of northwestern New Jersey), but also in my schooling. I was enrolled in a public school, and received additional training from a superb itinerant teacher of the state Commission for the Blind. Again, several of my public school teachers had an abiding interest in shells and plants, and their enthusiasm again reinforced that of my family.

From that point on, my interest in biology was encouraged and satisfied largely outside the confines of the classroom. In high school, I had an excellent course in chemistry, and I enrolled in the Science Honors Program at Columbia University. Rarely were attempts made to design experiments for me, or even to adapt existing materials to my needs; but then I rarely asked that this be done. I was encouraged to look at preserved animals, at skeletons, and at models of cells and molecules. Many of the science courses were simplistic or dull, but in none was I hidden away or excused.

The only significant resistance to a career in biology came when I was about to enter Princeton University as an undergraduate. My freshman advisor, together with a committee of distinguished faculty whom he had recruited for help, enthusiastically endorsed the idea that I should study biology; but the state agency that provided much-needed funds for readers held that biology was quite unsuitable as a profession for a totally blind student, and that if I persisted in electing science as a subject for concentration at all, I should perhaps favor paleontology. This was just fine with me: the discipline as taught at Princeton required a thorough background in biology, and I was in fact very interested in fossils and in geology generally.

Nonetheless, a principle was at stake, and the state agency quickly gave in when the faculty asserted that if I wished to study biology, I should be permitted to do so. Incidentally, the state agency never again raised the issue, and generously provided reader funds and some permanent equipment during my undergraduate and graduate years.

Princeton was an intellectual joy, and I received great quantities of enthusiasm from all quarters. Much the same can be said about Yale University, where I pursued graduate work that culminated in a Ph.D. degree in 1971. After I managed to convince the director of graduate studies during an admissions interview that I could meet whatever challenges graduate study in biology brought with it, the director became a committed supporter. While at Yale, I obtained outside funding from various sources for my dissertation work which carried me around the world.

Immediately upon leaving Yale, I came to the University of Maryland as an instructor in zoology. By 1974, I had received tenure as well as the rank of Associate Professor, which I presently hold. At Maryland, I have been thoroughly accepted by staff and students alike. I teach courses at all levels, and pursue a very active research program generously funded by the National Science Foundation and other sources. In 1975, I was awarded a John Simon Guggenheim Fellowship.

■

Parents and teachers alike saw to it that I experienced many objects and phenomena, either directly or through good illustrations . . . . Usually, teaching could be done effectively by using already available materials, or by making minor modifications in them.

I feel that I have been exceedingly lucky. Parents and teachers alike saw to it that I experienced many objects and phenomena, either directly or through good illustrations. Besides the usual Braille typewriters and a few other writing and mathematical accessories, as well as volunteer-produced textbooks, I have almost never used materials or equipment specially designed to teach science to the blind. Usually, teaching could be done effectively by using already available materials, or by making minor modifications in them.

I believe that science education for the blind, and indeed integration of the blind into regular classes, can be achieved with a relatively modest investment. In my view, the emphasis should be on itinerant teachers who can supplement the education of the blind pupil, rather than on expensive technology that must be devised especially for the blind. Moreover, I believe that the blind, like the sighted, should be exposed to a great variety of objects, phenomena, and other experiences. This will involve handling things, as well as learning how to interpret and make illustrations or models. After all, we cannot very well teach science if we isolate the student from the world in which she or he lives.

John Gavin

Research Biologist, Allergy Research Affairs, Miles Laboratories, Elkhart, Indiana

At the age of 34, John Gavin was chief microbiologist at a food and drug research laboratory and father of five children. He became deaf suddenly, the result of an allergic reaction to the antibiotic dihydrostreptomycin (since removed from the market as unsafe). Now, John Gavin, Ph.D. and father of nine is Director of Allergy Research Affairs. Although located in Elkhart, Indiana, he coordinates the allergy research projects for Miles Laboratories located in Slough, England; West Haven, Connecticut; Notre Dame, Indiana; Paris, France; and Copenhagen, Denmark.

When he lost his hearing, John Gavin suddenly lost contact with family, friends, and professional associates.

When he lost his hearing, John Gavin suddenly lost contact with family, friends, and professional associates. Soon afterwards, he lost his job. "Engulfed in a sea of self-pity, frustration and despair, he writes, "it took a while for me to find myself and gain some measure of control. The realization that six people depended upon me was a step towards a realistic approach for a solution." Dr. Gavin learned that in order to survive he had to develop self-discipline and self-understanding. He feels great appreciation for those people who helped him throughout his career.

Dr. Gavin's first step had to be learning a new method of communicating. Since he could not use a hearing aid, he enrolled in lipreading courses, expecting an easy solution to a difficult problem. But many sounds in English look alike, and many consonant blends and homonymous words are confusing. But he made progress, learning to understand his teacher and fellow students, and gradually gained some proficiency with close associates. Some people are easy to lip-read, some almost impossible. Lipreading requires a lifetime of practice and effort. Recently, Dr. Gavin has begun learning sign language so he can communicate with other deaf people about their education and jobs.

Even after Gavin learned to lip-read, it was difficult to find work. Every excuse was given from possible injury on the job to not being able to use the phone. One prospective employer told him that "competence was not enough." Although discouraged from repeated rejections, Gavin used these experiences as opportunities to learn how to make himself more employable. Sixteen months after losing his hearing, he was hired by a research laboratory for clinical investigation of new drugs. Gavin identifies this as the turning point of his career.

. . . "once and for all I could prove that physical disability need not interfere with competence . . . The psychological boost was invaluable."

While working at the laboratory, Gavin decided to return to his alma mater, Rutgers University for doctoral studies in bacteriology. During his studies, Shirley, his wife, assisted by typing transcripts of taped class lectures. With her help, financial assistance from his employer, and a grant from the National Institutes of Health, he earned his Ph.D. in 1964. With his Ph.D., Gavin found a new job at a relatively high level of management in the Dome Division of Miles Laboratories in West Haven, Connecticut. He found challenge and opportunity at Dome Laboratories and felt that "once and for all I could prove that physical disability need not interfere with competence . . . The psychological boost was invaluable."

In 1971, Gavin left Dome Labs for a position as Director of Molecular Biology Research for Miles Labs in Elkhart, Indiana. His career has included research in allergies, anesthesia, mental retardation, metabolism, vitamins, antibiotics, disinfectants, food preservation and infectious disease. He is a family man, researcher, inventor and writer. His resume lists 44 published articles.

Deafness has not kept him from travelling or from conducting business as usual on the telephone. Unless otherwise instructed, his secretaries do not tell first-time visitors or telephone callers that Dr. Gavin is deaf. When he uses the phone, a secretary listens on another telephone repeating the caller's words so that Dr. Gavin can lip-read and reply using his telephone. In his recent position he has visited several countries in the past few years, including England, France, Denmark, Czechoslovakia, and Hungary.

■

Deafness has not kept him from travelling or from conducting business as usual on the telephone . . . . When he uses the phone, a secretary listens on another telephone repeating the caller's words so that Dr. Gavin can lip-read and reply using his telephone.

Dr. Gavin has devoted much time in recent years to promoting the cause of employment and advancement of handicapped scientists. His efforts were instrumental in starting the AAAS Project on Handicapped Individuals in Science in the Office of Opportunities in Science. He was a delegate from Indiana to the White House Conference on Handicapped Individuals. This year he received the Chairman's Commendation Award from the President's Committee on Employment of the Handicapped. Also, in June of this year, Dr. Gavin received the Sidney F. Kramer Award for meritorious service to the handicapped from the Indiana Rehabilitation Services Board.

American Association for the Advancement of Science, Access to Science, *VI no. 2, September 1977.*

3

Preparing Teachers to Work With the Handicapped

3

Preparing Teachers to Work With the Handicapped

Introduction

The goal of providing a meaningful education for handicapped students in an appropriate environment is meaningless unless teachers have the knowledge, skills, and attitudes essential for the implementation of desirable programs. In the past teacher education programs have not systemically included the teaching of handicapped students as an integral part of the preservice program for regular classroom teachers. Preservice programs are now being modified to include the teaching of handicapped students in the regular classroom as an essential part of the teacher preparation program.

A detailed description of a university's efforts to modify its preservice program so the regular secondary school teachers can acquire the competencies necessary for working with handicapped students is described in this chapter. In addition, an innovative university project which integrates the acquisition of science content and competencies to teach science to handicapped elementary school children is reviewed. A junior high teacher tells how she tried to maintain normalcy in her science class when she suddenly found a partially sighted student sitting in the front row of her science class. Another author relates how a kindergarten teacher used science activities with a group of handicapped children to help achieve the objectives of the kindergarten program. Some possible fears and apprehensions of both teachers and handicapped students in a mainstreaming situation are identified and suggestions for overcoming these problems are presented. A discussion concerning the need for handicapped students to be accepted as individuals by both the teachers and other students illustrates the necessity of eliminating attitudinal barriers that may prevent full integration of handicapped students into regular classrooms. The potential value of studying science instruction in special education resource rooms as a means of improving science instruction in the regular classroom is proposed in the chapter.

Model for Preparing Teachers in Science for Handicapped Students

Donald W. McCurdy
The University of Nebraska, Lincoln, Nebraska

After a long and complicated legislative and judicial history, the Education for all Handicapped Children Act became Public Law 94-142 when President Ford signed the measure on Nov. 29, 1975. This milestone legislation provides for a permanent federal obligation to help school districts raise the quality of education for the nation's eight million handicapped children to a new standard of excellence and opportunity.

Recent court decisions and new laws in many states have determined that handicapped children have the same edcational rights as other children—that they are entitled to education according to their needs. It has also been determined that these needs should be met at public expense—either in special or regular classes or some combination of the two. School programs and facilities must be modified accordingly.

It is obvious that Colleges of Education must also make necessary modifications in their programs to prepare regular classroom teachers who are competent to work with handicapped children.

It is obvious that Colleges of Education must also make necessary modifications in their program to prepare regular classroom teachers who are competent to work with handicapped children. The classroom teacher can no longer assume that handicapped youngsters will be carted off to special schools or special education classrooms. Under the principle of "least restrictive" environment, marginally handicapped children will be the responsibility of the "regular" classroom teacher. The special education teacher will become a "resource person" who will help the regular teacher with diagnosis, prescription, and the identification of specialized instructional materials.

Institutions of higher education have responded in various ways to the challenge of preparing teachers for working with handicapped youngsters. Some states (e.g., Missouri) have mandated courses to prepare teachers for mainstreaming.

At the University of Nebraska—Lincoln, it became apparent that establishment of a specific course relating to the education of the handicapped in the regular classroom was inappropriate on several dimensions. The most critical of these was that a separate course would be philosophically inconsistent with the concept of regular education participation in the education of the handicapped; this would tend to perpetuate a segregation of regular education and special education functions. In light of this consideration, an approach which would integrate instruction and practicum experiences with handicapped students into the existing program was seen as the best alternative. We have chosen to integrate mainstreaming concepts, principles, and experiences throughout the professional sequence. For example, in the freshman level "Introduction to Education" course, such topics as the historical, for practicing and demonstrating selected skills. The other half of the semester is spent in a public school where the student functions as a teaching assistant. The assistant's responsibilities begin with limited one-to-one tutoring experiences and such duties as helping to set up laboratory activities. Duties gradually expand until by the end of the semester the individual may be responsible for whole class instruction for several days at a time.

■ *We have chosen to integrate mainstreaming concepts, principles, and experiences throughout the professional sequence.*

Many students are assigned to work in teams of three or four with a single cooperating teacher. Leadership roles may be rotated among the team members so that by the end of the semester the individual will have been responsible for planning a week of instruction and providing the team leadership for that week.

Since most of the classes in which the NUSTEP students are assigned are general education courses, many of them contain mainstreamed students with various kinds of handicaps. This provides excellent opportunities for developing the specialized skills needed for working with atypical students.

The NUSTEP program is based on a set of basic generic competencies to which the staff is committed. These competency statements are organized about the six basic roles of a teacher:

1. The Teacher as Instructional Planner
2. The Teacher as a Director of Learning Experiences
3. The Teacher as Assessor and Evaluator
4. The Teacher as Humanizing Agent
5. The Teacher as Professional Educator
6. The Teacher as a Subject Area Leader

Examples of competencies under role 1. The Teacher as Instructional Planner are:

1. The teacher identifies and diagnoses learner needs.
2. The teacher specifies desired learner outcomes (objectives) to meet diagnosed needs.
3. The teacher determines assessment criteria for each outcome.

4. The teacher plans learning activities to achieve desired outcomes (objectives).

For the past three years, the University of Nebraska—Lincoln has operated a project funded by the Bureau of the Handicapped entitled "Educating the Handicapped in the Regular Classroom." One of the outcomes for this project is a set of competencies for regular classroom teachers in regard to their work with handicapped students. These competencies are presently in the process of being incorporated into the NUSTEP project and other segments of the teacher education program. Some of these competencies are listed here:

1. Recognize the developmental sequence in the tool subject areas of language, reading, mathematics, science, etc.

2. Demonstrate the knowledge of basic etiology of exceptional children.

3. Be able to identify or diagnose learning problems and other handicapping conditions.

4. Plan for individualized instruction in the classroom through use of all the available support personnel within the school setting; resource teacher, educational strategist special education teacher, speech and hearing personnel.

5. Will be able to identify the human resources available and match resource personnel to student need.

6. Recognize and identify sources for educational media materials for handicapped children.

7. Identify and explain functions of community resource agencies.

8. Know the background of legislation concerning the handicapped child in the regular classroom.

9. Recognize and be able to relate the current legislation and know the role it plays within the classroom.

Competency Development Through Modules

The NUSTEP project is divided into two major segments—the generic portion which deals with competencies needed by all teachers regardless of discipline and the subject area portion which pertains to the skills and knowledge peculiar to the discipline. Examples of the generic modules are:

1. Teaching Methods for the Classroom

2. Task Analysis & Behavioral Objectives

3. Assessing Student Performance

4. Cueing: Nonverbal, Questioning, Set & Closure

5. Classroom Management: Reinforcement Principles, Contingency Contracting

6. Individual Differences

A copy of module 6, Individual Differences, may be found in the appendix of this paper.

The science education component consists of a series of fifteen modules. Some of the titles of these modules are:

1. Inquiry Teaching Strategies

2. Selecting Content and Materials in Science

3. Curriculum Development in Science

4. Long Range Planning in Science

5. Laboratory Instruction

The modules are presented in a variety of formats including lectures, discussions, self instructional mediated materials, and individual contracting. Microteaching experienes are provided as a means for students to practice and/or demonstrate particular skills. Often these sessions are videotaped for subsequent analysis by the student and/or his or her supervisor.

Each module consists of the following parts:

1. Student Guide—a set of instructions on how to complete the module.

2. A problem statement—an orientation to the purpose of the module.

3. A module overview.

4. Behavioral objectives.

5. An "On Campus Work Sample"—a written or oral sample of the students' work pertaining to a simulated teaching situation.

6. An "Off Campus Work Sample"—a written or oral sample of the students' work pertaining to a real teaching situation in a public school.

7. Check lists for the work samples—these check lists enable the student to insure that s/he has provided for all the essential components.

8. Skill Acquistion Section—this section identifies various printed and mediated materials which deal with the various objectives of the module and are available in the Media Center or University Library.

A copy of the Individual Differences Module is provided in the appendix of this paper as an example of how the NUSTEP modules are adapted to insure attention to the needs of handicapped children. For examples, three objectives from this module are as follows:

> "The student will be able to identify at least one change in classroom arrangement that would facilitate mainstreaming of handicapped individuals."
>
> "The student will be able to describe two potential modifications of materials and/or format that would facilitate mainstreaming for individuals with handicaps."
>
> "The student will be able to describe at least two ways in which objectives and assessment procedures could be modified to facilitate mainstreaming of handicapped individuals."

An example of an off campus work sample is as follows:

"For the off campus work sample you will:

1. Read the case of Mary (Mary is a fictitious physically handicapped youngster who is confined to a wheelchair.)

2. Analyze the classroom environment of your teacher assisting setting relative to meeting Mary's needs.

3. Analyze your teaching style, or the one(s) to be used in teaching your unit, relative to Mary's needs.

4. In your off campus setting, identify who would be involved in a staffing/referral process for the case of Mary, and briefly describe their roles.

NOTE In completing this work sample, assume that Mary is a handicapped student who is to be mainstreamed in "your" classroom (one similar to your teacher assisting setting) while you are teaching your unit plan."

All of the generic and many of the subject area modules contain references to various handicapping conditions. Students are required to respond in terms of how they would handle various problems and opportunities created by having handicapped children in the classroom.

In the science modules students are asked to indicate how they would adapt various laboratory activities for students who are orthopedically handicapped or students who are blind or visually impaired. Students are also required to consider how the selection of content and materials might be influenced by the presence of various types of handicapped children. The choice of curriculum materials is another place where students must consider the special needs of handicapped children.

There is very little current professional literature in this field. Recent articles by Weems[1] and Baughman and Zollman[2]which describe physical science laboratory courses for the physically impaired and blind respectively are rare examples of work in this field. More work has apparently been done at the elementary level than in the secondary schools. The March 1976 issue of *Science and Children* was devoted entirely to science for the handicapped.

Much research and development work remains to be accomplished in the area of science for the handicapped. It is a fertile field that must be cultivated in the near future if science teachers and science educators are to respond adequately to spirit as well as to the requirements of Public Law 94-142. Legislation alone, without the enthusiastic support and commitment of the teaching profession, will not get the job done.

---

[1] *Bruce Weems, "A Physical Science Course for the Visually Impaired,"* The Physics Teacher, *Sept. 1977, pp. 333-338.*

[2] *James Baughman, Jr. and Dean Zollman, "Physics Labs for the Blind,"* The Physics Teacher, *Sept. 1977, 339-342.*

NUSTEP

Credits

Dr. Don McCurdy	Nustep Project Director, Department of Secondary Education
Dr. Royce Ronning	Teaching Council Grant Administrator Project Coordinator, Department of Educational Psychology and Measurements
Dr. Roger Bruning	Consultant, Department of Educational Psychology and Measurements
Spencer Ward	Editing and Module Development
Chris Petersen	Audio-Visuals and Module Development
Cal Stoltenberg	Module Development
Pat Thompson	Module Development

This project was made possible by a Teaching Council Grant, UN-L

Materials Revision and Production 1977

Robert Saf	Consultant, Education Coordinator, Mainstream Grant
Chris Petersen	Module Design and Development
Dave Prentice	Module Design and Development
LaJean Hadenfeldt	Editing and Typing

Student Guide

1. Read the *Problem Statement* and the module Overview. Try to predict the sorts of behaviors you will be learning in this module.

2. Read on *On Campus* and *Off Campus Work Samples* which describe your tasks for the module.

3. Pay particular attention to the *Work Sample Checklist* which forms the basis for evaluation of your work in this module.

4. Decide whether or not you can complete the *On Campus Work Sample.* If you feel that you must first acquire more information and skills complete the tasks in the *Skill Acquisition Section* choosing carefully those items you think can help you.

5. A. Complete the *On Campus* work sample using the Work Sample Checklist as an outline.

   B. Fill out the Work Sample Checklist and then attach the checklist to the *On Campus* work sample.

6. A. After meeting all the criteria in the *On Campus* work sample, complete the *Off Campus* work sample in your TA setting.

   B. Fill out the Work Sample Checklist and attach the checklist to the *Off Campus* work sample.

7. You will receive credit for this module upon meeting all of the criteria for all of the *Off Campus* work sample.

Problem Statement

Remember when you entered a new class not knowing any of the other students, and feeling uneasy about how you would behave? Remember the blur of faces, so indistinguishable at first, and yet so different after you became a member of the group? As you got to know them, the differences among members of the class resulted in your making decisions, decisions such as with whom to eat lunch, with whom to study, with whom to double-date. Sometimes those early decisions were good ones, sometimes not.

Each time a teacher meets a new class the same experience occurs. The teacher sees a blur of faces, but after only a few class meetings certain differences among individuals begin to stand out. Because student groupings do tend to be heterogeneous, it is essential that teachers be able to make appropriate instructional decisions for a wide range of student needs. As a result of "mainstreaming"—which provides that mildly handicapped students be educated in the least restrictive environment that meets their needs—the least restrictive environment for most mildly handicapped students will be the regular class. Thus, the regular class teacher may have an even wider range of student differences to contend with. The purpose of this module is to help you deal rationally with questions as:

> "What sorts of differences among students *should* lead to alternatives in how I teach?"
>
> "When I am faced with a wide range of student differences, particularly in the case of having a mildly handicapped student in the class, how do I adapt to them?"
>
> "Can I behave in such a way that *each* student will learn to his potential?"

Clearly, books could (and have been) written about individual differences among us humans. Since we are not writing a book, this module will focus on individual differences along two related dimensions.

a. The heterogeneous nature of classrooms as a whole, and . . .

b. The unique needs of mainstreamed mildly handicapped students.

Module Overview

The goal of this module is to make sure that on completion of the NUSTEP program you will be able to design a set of instructional experiences which will enable you to give maximum opportunity for learning to every student in the class. In the course of completing this module, you will investigate the nature of student differences (both "normal" and handicapped) and how those differences may affect your decisions about how a class should be taught. Particular emphasis has been placed on teacher skills in adapting instruction for the mildly handicapped student who has been placed in the regular classroom, i.e., "mainstreamed."

In the previous five modules you have learned the component skills essential in individualizing instruction. In the course of this module you will be studying the process of individualization in the broad context of the heterogeneous classroom, and more specifically, in the context of the handicapped student who is mainstreamed. In the *On Campus Work Sample* you will have an opportunity to analyze yourself as a learner and as a professional in the role of teacher. In the *Off Campus Work Sample* you will have an opportunity to analyze a case study of a handicapped student who could be mainstreamed in your classroom.

Behavioral Objectives for Module VI

> The Student Will Be Able To (SWBAT) describe his/her preferred mode of instructional input.
>
> SWBAT describe his/her preferred mode of instructional output.

SWBAT identify at least two individual characteristics which influence his/her learning style.

SWBAT describe at least two ways in which the NUSTEP program:

1. facilitates learning in their preferred style.
2. inhibits learning in their preferred style.

SWBAT describe at least two ways in which the NUSTEP program:

1. individualizes instruction to meet the heterogeneous needs of students.
2. could be modified in order to facilitate learning by all students.

SWBAT identify at least one change in classroom arrangement that would facilitate mainstreaming of handicapped individuals.

SWBAT describe two potential modifications of materials and/or format that would facilitate mainstreaming for individuals with handicaps.

SWBAT describe at least two ways in which teaching style could be modified to meet the needs of an individual learner.

SWBAT describe at least two ways in which objectives and assessment procedures could be modified to facilitate mainstreaming of handicapped individuals.

SWBAT describe at least two ways of evaluating the progress of a mainstreamed student.

SWBAT identify at least one responsibility of the regular classroom in:

1. the referral process.
2. the staffing process.
3. the implementation of the IEP.

SWBAT identify those persons who would be involved in the referral and staffing process in an off campus setting *and* be able to identify at least one responsibility for each person/role identified.

A. On Campus Work Sample

For the *On Campus Work Sample* you will:

1. Analyze your own unique learner style.

2. Analyze the effectiveness of the NUSTEP program in meeting your needs as learner.

3. Analyze the effectiveness of the NUSTEP program in meeting the needs of at least two handicapped students.

4. After viewing the NETCHE Tapes on "mainstreaming," analyze your future role as a teacher who is a participant in the staffing process.

NOTE

1. It is essential that you view all *three* NETCHE tapes on mainstreaming before attempting to complete this work sample.

2. It is suggested that this work sample be completed in conjunction with any "self-analysis" project you complete in your discipline area (Spiral II).

Checklist* Module 6 on Campus Work Sample

I. Learner Style:

  A. Describe your preferred source/means of instructional "input" ("how you learn best"—i.e., reading, media, etc.).

  B. Describe your preferred source/means of instructional "output" ("how you report best"—i.e., written, oral, etc.).

  C. Describe at least two other individual characteristics which influence your learning style (i.e., cultural background, married and have a family, etc.).

II. Learning Environment—NUSTEP Program:

  A. Describe at least two ways in which the NUSTEP Program:

    1. facilitates learning in your preferred style(s).

    2. inhibits learning in your preferred style(s).

  B. Describe at least two ways in which the NUSTEP Program:

    1. individualizes instruction to meet the heterogeneous needs of your NUSTEP class.

    2. could be changed in order to better meet the individual needs of your NUSTEP class.

C. Identify at least two handicapping conditions which are or could be present in your NUSTEP class.

1. Cite at least one change in the classroom arrangement that would be necessary in order to mainstream individuals with each of the handicapped conditions (identified above) in your class.

2. Cite at least two potential modifications of materials and/or format that would facilitate the mainstreaming of individuals with each of the handicapped conditions (identified above).

3. Describe at least two examples of how objectives *and* assessment procedures used in your NUSTEP class could be modified to facilitate mainstreaming individuals with the handicapping conditions identified above.

III. Classroom Teacher in a Consulting Situation:

A. Identify at least one possible responsibility of the classroom teacher:

1. in the referral process.

2. in the staffing process.

3. in implementing the Individual Education Plan (IEP) drawn up in the staffing.

*Student and Supervisor checks off each item on the work sample.

B. Off Campus Work Sample

For the *Off Campus Work Sample* you will:

1. Read the case of Mary.
2. Analyze the Classroom Environment of your TA setting relative to meeting Mary's needs.
3. Analyze your teaching style, or the one(s) to be used in teaching your unit, relative to Mary's needs.
4. In your Off Campus setting, identify who would be involved in a staffing/referral process for the case of Mary, and briefly describe their roles.

NOTE

1. **In completing this work sample, assume that Mary is a handicapped student who is to be mainstreamed in "your" classroom (one similar to your TA setting) while you are teaching your unit plan.**

2. **In identifying the people involved in the staffing/referral process, use NETCHE Tape #2 as a reference. Note that in the Off Campus setting you may not be able to identify all of the roles/people presented in NETCHE Tape #2.**

Checklist* Module 6 Off Campus Work Sample

I. Analysis of Classroom Environment:

  A. Describe the classroom environment of your off campus (TA) setting.

    1. Describe at least one modification, if needed, of the physical arrangement that would facilitate the mainstreaming of Mary. (How are the students seated? Are they in rows, or perhaps in a cluster of desks? If Mary's strengths are her personal/social skills, would one particular seating arrangement be better than another? Why?)

    2. Describe the textbooks. Identify their reading level, and if needed, cite an example of how you would adapt the text materials to Mary.

II. Analysis of Teaching Style:

  A. If you were the teacher in your (TA) classroom, identify your preferred teaching style (i.e., mainly lecture, student notes, small groups, etc.).

  B. Describe, if needed, at least two ways that you would change your teaching style for Mary.

  C. Describe two ways you would choose to evaluate her progress. (Remember, she has poor eye-hand coordination. Would you give her a written test with only a short time to write the answers?)

III. Referral/Staffing Process

  A. In your TA setting report who would be involved in the *referral* and subsequent *staffing* for Mary.

    1. Identify one responsibility for each person.

*Student and Supervisor checks off each item on the work sample.

C. Skill Acquisition Section

Here you will find the skill acquisition sources for both the On and Off Campus Work Samples. You will note that the readings are grouped somewhat differently from the pattern in the other modules; they *do not* directly correspond to the headings on the checklist. It is anticipated that you will view all three NETCHE tapes (found under C. Job Roles) before completing the work samples. Also, you will need to read the case of Mary (found in 2. a. iii.) in order to complete the Off Campus Work Sample.

1. Heterogeneous nature of classroom as a whole.

   A. Socioeconomic and cultural differences:

      i. *The Way It Spozed to Be,* J. Herndon, pp. 25-50 (book).

      ii. "Cultural Differences" (videotape).

      iii. "What is Poverty," Jo Goodwin Parker (article).

      iv. *Mainstreaming: The minority child in regular classes,* Jones (book).

2. Unique needs of mildly handicapped mainstreamed students.

   A. Range of individual differences:

      i. *Psychology for the Classroom,* Gibson, pp. 377-404 (book).

      ii. "Interpreting Measurement Statistics" and "Characteristics of Measuring Instruments" (articles).

      iii. "Mary: Multiple-Handicap Assessment" (article).

   B. Assessing teacher-learner style:

      i. "Learning Styles," Maryland Tape #7 (videotape).

   C. Job roles:

      i. *Mainstreaming Exceptional Children: How To Make It Work,* John A. Glover and Albert L. Gary, pp. 36-57 (book).

      ii. *Exceptional Children in Regular Classrooms,* Maynard C. Reynolds and Malcolm D. Davis (Eds.), pp. 64-70 (book).

iii. *Mainstreaming: Origins and Implications,* pp. 5-7 (book).

iv. *Trends in Education,* Maynard C. Reynolds, pp. 0-0 (book).

v. NETCHE Tapes, I, II, and III (videotape).

Science for a Partially Sighted Junior High Child

Susanne C. Johnston
Telford, Pennsylvania

During the first few hectic days of school when one is confronted not only with new faces, but new equipment and desk supplies to put away and the endless array of faculty meetings, educators in our building are usually informed of what our district terms as "atypicals." An "atypical" child is one with a handicap or a malady which could endanger his well being (allergies, hearing loss, epilepsy, etc.). Traditionally this list is presented during the first week of school, however, we usually have met with each of our classes several times before this information is disseminated.

Imagine my own (not to mention that of my class) surprise and confusion when I saw an attractive, mature looking student with glasses (whom I accidently placed in the front row) reading a paper pressed up against her nose so tightly that it left ink marks . . .

Imagine my own (not to mention that of my class) surprise and confusion when I saw an attractive, mature looking student with glasses (whom I accidently placed in the front row) reading a paper pressed up against her nose so tightly that it left ink marks, who volunteered for everything but then read so slowly that it took extreme patience to wait for her to complete a sentence, who would write with her cheek on the paper, pen pressed beside her nose and hair cascading over her paper and desk, and who would ask me to slowly repeat every sentence I had just *written* on the board. More confusing still was that she could find her way around the building without the use of another student or sight aids. Since I had not yet been alerted to her problem and since her symptoms seemed inconsistent, I was not sure if I had a student with a severe problem.

I was later to find that Tracy had congential cataracts and had been mainstreamed.

First You Cry

On a nationally broadcast government sponsored commercial a mother exclaims, "When you find out your child is retarded, first you cry, then you get angry, then you do something about it." This was my exact reaction when I found out I was to have a "legally blind" student in a class with normally sighted students.

At first I felt extremely sorry for Tracy. How was she going to see slides in the microscope, chemical changes, the ruler when we studied the metric system? How could she use a scale, or a graduated cylinder or an alcohol lamp? How would she see our films or enjoy our field trips? I became aware of how visual our science curricula is and how dangerous it could be for her.

■

Then I was enraged to think that my school district should expect me to assume responsibility for this child's science education.

Then I was enraged to think that my school district should expect me to assume responsibility for this child's science education. I was totally unprepared, in fact I was not even told ahead of time so that I could have scraped something together. I had no background experience in teaching the handicapped nor coursework to help me fill in the gaps. I was furious because the district offered me no help either in the way of special supplies or even coursework.

All of these thoughts and feelings flooded me within the first few minutes after I was told of her handicap. When I began to rationalize and reflect back to her first few days in class, I remembered how matter of fact it had all been to Tracy. She had not even asked for preferential seating nor had she brought a note from home to explain her malady. After all, I reflected, things had always seemed this way to her. She had been born with her handicap thus she had never know what she was missing. Reading a paper pressed to her nose and using a telescope to read the board and writing with a pen next to her nose were all instinctive to her. She did it automatically.

I also reflected back to the reactions of her peers those first few days. Almost no one in the class had known Tracy previously so no one was acquainted with her handicap. They were uncomfortable and restless when she would read or volunteer. While no one made fun of her, I could sense a feeling of repulsion. After all they thought this "kid was wierd." Anyone who is the least bit different in junior high is a "reject" and Tracy was far from "a little" different. I had my work cut out for me.

A Discussion of the Obvious

As soon as I discovered what was going on, my first two assignments were to ask Tracy to explain her handicap to the class and to assign another student to work with her. From past experience, I have discovered that most people enjoy discussing their handicaps but I asked Tracy first so she would not feel humiliated. She was, indeed, delighted to comply. She explained what her handicap was and that it was the result of her mother having rubella during her pregnancy. She described her limitations and allowed the others to look through her telescope. It seemed to put the class at ease and they had many questions to ask both of us.

Choosing someone to work with her was a more difficult assignment. It had to be someone who was Tracy's equal in all ways and mature enough to accept and maintain the responsibility. Only someone who has worked with 11 to 13 years olds can understand how unstable the emotions of this age group are. To select someone who would be inconsistent, impatient, intolerant or inconsiderate at anytime would be disastrous not only for Tracy but for the class. I had to chose someone who would be likely to associate with Tracy socially, someone who would be willing to work with Tracy no matter how slowly or tediously the work might progress, someone who would be consistent in helping Tracy through the whole year, someone who would do what needed to be done without being reminded and above all someone who was sensitive but not overly sympathetic. Fortunately, I was able to find the right combination without having known the students for too long—a stroke of good luck!

Finding a suitable helper is probably one of the most important decisions you will make regarding a handicapped child. Courtney, Tracy's aid, takes notes for her, reads what is on the board and is her eyes, describing all that she sees that she thinks is necessary for Tracy's information. Above all, she is Tracy's friend. She does not pity Tracy and many times marvels at Tracy's capabilities considering her handicap. She keeps her eyes on what Tracy is doing and if she anticipates any danger that I have not spotted first will prevent an accident. She is also able to deal with those frustrations that Tracy might have or suggestions I might have to help them both. These are all assets that many adults do not have, let alone an adolescent. Although I was fortunate on the first try, it might involve several combinations before you will find the right team. The fact that Tracy is an undemanding, mature, patient, self-motivated, and above normal in intelligence, helps too. Not all handicapped children are so well adjusted to their handicap. A child who has acquired a handicap after birth will probably have more emotional problems which I did not have to deal with.

Courtney, Tracy's aid, takes notes for her, reads what is on the board and is her eyes, describing all that she sees that she thinks is necessary for Tracy's information. Above all, she is Tracy's friend.

Setting Up the Classroom

Here are some things that were done to suit the classroom to Tracy's handicap:

1. If I have time, I type all my notes in capital letters. If I do not have time, I give her aid carbon paper so she can take notes for both of them.

2. I give Tracy all tests and quizzes typed in capital letters.

3. If students are to do research which is lengthy, I show Tracy the paragraph the information is located in so she does not have to plow through a lot of irrelevent material. If the material is concise I show her how to find information, it is not necessary to exhaust and frustrate her by having her read for an hour to find one fact. While she can read, she can do so at about one-fifth normal speed.

4. If there is an experiment to be done. I usually station myself close to her table in case she should put her hand or hair into a flame or chemical, etc. I attempt to allow her to do as much hands on work as possible but I try to keep one eye on her at all times.

5. If there are any instructions, I type them in capital letters and/or read them to her to save her time.

6. We have a service which will blow up textbook pages for her use. They must be, however, submitted to the service at least one month in advance.

7. I supply her with our largest equipment, not only in size, but also in print for ease of manipulation.

8. I have Tracy work with different team mates in addition to her aid so that she can experience working with different people and can experience different styles of reasoning.

9. I allow Tracy extra time in class to work on tests and at home to work on written and reading assignments.

10. In all cases Tracy participates. I try only to remove the element of danger or frustration.

While all of these things may seem painfully obvious to the experienced, they were things I had to discover along the way. Hopefully these observations will make it easier for others.

To prepare the other students to work with Tracy, I tried some of the following activities.

I wish to apologize, prematurely, for any plagerism that might result here. I am not suggesting that these are all my own original ideas. Since I have been teaching for eleven years it is difficult to remember exactly where all of my techniques have originated from.

Paper Towel Test

I used this experiment to sharpen the visual observational powers of the entire class. Each team of students (3-4 in a group) puts a paper towel (same brand) folded lengthwise into a 250 ml. beaker of water which is half filled. They are to make as many observations as they can about what is occuring in 15 minutes. Most teams average forty to fifty observations. Although statements such as there are bubbles in the water or bumps on the paper towel may seem trite they are, none-the-less, observations. I then have each team, one at a time, contribute one of their observations. These are recorded on the board. Observations cannot be repeated by another team. This helps to prepare students who will work with Tracy, learn to make verbal observations of visually obvious events for her benefit. It is also a good scientific practice.

■

This helps to prepare students who will work with Tracy, learn to make verbal observations of visually obvious events for her benefit. It is also a good scientific practice.

Observation vs Interpretation

After all the observations the class can contribute concerning the paper towel lab are recorded on the board, we discuss the difference between an observation and an interpretation. Students are then instructed to remove from the list all interpretations, so that only observations remain. Comments such as "the bubbles in the water come from oxygen in the towel" are deleted. This serves to remove bias from observation before it is tested. Again, this is to help Tracy's lab partner but also to help students in the scientific method.

Capillary Action and Chromatography

As a follow-up to see if the students did indeed know the difference between observations and interpretation and if indeed they are able to make good observations, I give them a simplified capillary action and chromatography lab to do. Since it is a spin off on the paper towel lab, they must describe to Tracy in as much detail as possible what they are observing. They are given three glass tubes of varying sizes which they place in colored water. After they observe what has taken place, I have them relate this to what has happened in the paper towel test. Tracy records while the other children measure, experiment and observe. Thus both parts of the team feel they have contributed and Tracy can construct her own image of what has taken place. I then give several pieces of chromatography paper. On each piece I put a different food color. Lab teams suspend these in beakers so that they just touch the water. Again they measure and observe while Tracy records. By this point many students have started to try things on their own—why do different colors separate while others have not, would different liquids in the beaker yield different results, what if I folded the towel differently? It offers a terrific lesson in scientific-methodology, sparks creativity and above all it involves Tracy and her classmates in an interchange of observations and ideas.

■

Tracy records while the other children measure, experiment and observe. Thus both parts of the team feel they have contributed and Tracy can construct her own image of what has taken place.

Sensitivity Sessions

These activities were used to create awareness of Tracy's handicap in the normally sighted students.

You have undoubtedly heard of the black box experiment. Each student brings in an object in a cardboard jewelry box which is taped shut. They exchange boxes and try to determine what is in the box without looking at or touching what is inside. Another variation of this is to paint babyfood jars so that nothing can be seen and to place things inside such as sand, syrup, a metal washer glued to the inside, etc. Students determine what is inside by rolling them down a ramp.

Another sensitivity session involves the pairing of students. They must choose someone they trust. One student is blindfolded while the other takes him on an awareness walk. The unblindfolded partner may not lead his partner but must describe to him how to walk. The blindfolded student is urged to touch, listen, and smell his surroundings and attempt to identify his location. The partners then switch. Students relate their feelings when they return to class. In all cases students usually report disorientation and a heightening of their other senses.

On pleasant days students can be taken outside. The class should sit in a circle and close their eyes. Each student contributes one observation about something he senses in his environment. Observations may not be repeated. As can be imagined, Tracy excelled at this and helped give her classmates many ideas about what to concentrate on.

Getting the Handicapped Involved

Partially sighted students should be permitted to participate in classroom activities to their fullest extent. The following exercises represent some ways in which these students may participate.

Microscope Work

I found much to my surprise, that Tracy was able to see some things in the microscope. Perhaps because she could focus it to the strength she needed. Her lab partners also helped her by describing the pictures and in helping her to sketch them thus giving her a tactile sense of the picture.

Food Lab

After a unit which deals with the compounds of protoplasm, I always have the students test different types of food to see what compounds they contain. I was a little concerned at first about Tracy's participation because of the element of danger but things worked out all right. We discovered that if we marked a graduated cylinder with a rubber band to show the correct amount of ml's needed, Tracy could tell how high to pour the liquid. (I think she determined it by the temperature difference because she couldn't see it). She would then pour it in a test tube and drop the correct piece of food in the tube. Her lab partners would then tell her what the color change was and would do any heating necessary. It is necessary to include these handicapped students in as much normal activity as possible and leave only the impossible to the other students. Tracy would have tired of being only the recorder. This gave her an opportunity for a little action.

■

It is necessary to include these handicapped students in as much normal activity as possible and leave only the impossible to the other students.

Optics and Disease

Because of her experience with her handicap, Tracy was aware of blindness related diseases. As she related the causes of these diseases, it sparked the classes' interest in studying diseases of the senses, their causes, preventions and cures. Her sight aids also caused a spin off unit dealing with lenses, amplifying instruments, artifical limbs, transplants, etc.

Genetics

After a study of a genetics unit, I conclude with a study of the classes' own gene pool. One of the tests we do is for color blindness which led to a discussion of sex-linked traits. The fact was brought up that hemophilia is a genetic disorder so as a group we discussed what decisions married people are faced with if they have a defective gene that might be passed on to their offspring. Tracy volunteered that her defect was a dominant gene and that although she would like to have children because she did not feel that severely handicapped, she realized it would be very expensive. Other students brought up the fact that perhaps her children would not be so well adjusted so maybe it would not be fair for her to pass this defect on. It created an excellent discussion and interchange of values. We then branched off into a discussion of what traits are inherited and which are not.

The Same As You and Me

Probably the most important thing to remember when dealing with any handicapped child is to maintain normalcy. Every child is going to become frustrated at some time. Tracy panics when she has something long to read or must take a test for fear she will run out of time. She has learned to put trust in me, however, and knows I will allow her extra time. Sometimes her classmates become frustrated because she has asked them to repeat something for the fourth time or because they forget momentarily about her handicap. Treating Tracy as though she is normally sighted, and shaping everyday activities to allow for her disability helps to make all involved forget that a problem exists.

■

A handicapped child will not profit by things being done for her. She, as anyone else, must learn how to do the best she can with what she has.

Awareness of the problem by the other students and the teacher is the key to helping the handicapped child, not sympathy. A handicapped child will not profit by things being done for her. She, as anyone else, must learn how to do the best she can with what she has. She must learn her capabilities and her own limitations. The best gift we as educators can give is to show her how to use her capabilities and how to deal with her limitations. The rest is up to her.

Accepting the Handicapped

Gregory Stefanich
Curriculum & Instruction, Education Center, University of Northern Iowa, Cedar Falls, Iowa

Orthopedically handicapped persons constantly encounter individuals who react very uncomfortably to them. It is most often a non-verbal expression of avoidance or pity.

Everyone needs to be accepted for herself/himself, to be included, and to be allowed to serve as support and inspiration to others. A teacher must be knowledgeable and competent in meeting the special needs of the handicapped. To successfully build a handicapped child's self-image, a teacher must first help other children develop healthy and positive attitudes towards these children.

Orthopedically handicapped persons constantly encounter individuals who react very uncomfortably to them. It is most often a non-verbal expression of avoidance or pity. Much of the reaction is often precipitated by a lack of knowledge and understanding of handicaps. As a seventh grade student who was stricken with polio in 1955, I found difficulty with peer acceptance and peer interaction to be a major problem area.

Science can do much to create a level of understanding through a thoughtfully conceived program which is enjoyable, instructional, and which leads to deeper understanding of the nature of physical limitations. This paper is directed toward providing a greater acceptance and awareness of orthopedic handicaps to educators who have a limited background and understanding of their limitations and compensations.

Goals

1. To provide an understanding of how to deal with and accept differences in people.
2. To promote the acceptance of handicapped children as individuals, more like than unlike the other children, and to encourage their participation in regular group activities.

Definition

The *Orthopedically Handicapped* child is one who has a crippling impairment which interferes with the normal functioning of bones, joints, or muscles.

Included in this category are: (a) children who are born with handicaps, and (b) children who acquire a crippling condition later in life. Examples in each category are listed below:

1. Prenatal handicaps: (a) clubbed hands and feet; (b) absence of arms and legs; (c) defects in legs, neck or hips;
2. Persons who acquire a crippling condition later in life: (a) poliomyelitis; (b) muscular dystrophy; (c) arthritis; (d) tuberculosis of the bone; (e) osteomyelitis.

Establishing a Classroom Atmosphere

■

handicapped children have the same feelings as non-handicapped children

It is important that everyone recognize that how you feel dictates the basis on which you operate. Fellow students must recognize that handicapped children have the same feelings as non-handicapped children and have similar capacities to perceive what others are thinking. This will begin to materialize only after the non-handicapped are sensitized to the needs of the less fortunate. And what will be accomplished only after all children are equipped to live with one another with understanding and appreciation of the differences and disabilities within each one of us. It is important that we mix the abled and disabled together. Separated, the handicapped become isolated and therefore without influence. As a result they often find themselves to be almost totally dependent upon sympathetic but non-handicapped participants in the political process. Acceptance must be learned through showing and helping without indifference, fear or repulsion (Solomon, 1977).

Edward Solomon, a principal at Rachel L. Carson Intermediate School, explains that in helping the physically handicapped the element of mainstreaming must include other handicapped students as well. This will serve to the benefit of all concerned. He states:

> The inclusion of the full spectrum of handicaps was important for both the handicapped and for the normal child. To segregate the disabled child would allow him no opportunity to see another child overcoming a different handicap. Just as keeping him from full participation in a normal school setting deprives the handicapped child of learning to share and to accept and to understand people's differences, so would the exclusion of differently handicapped classmates keep him from a true appreciation of our diversified society. The normal child, who shares his school with students of varying abilities, must learn that there is a population less fortunate than he. Unlike the economically deprived, who can be helped by infusions of money into the schools, these people will always be handicapped, despite all the help they may receive. The normal child must learn to understand, to accept, and to work with people who are in any way limited in body or in mind. Only then will the normal majority come to accept their responsibility for providing for the handicapped on the basis of need rather than seeking ways of keeping them from entering and participating in the larger society (1977).

Attitudinal barriers associated with guilt and avoidance by normal persons and adaptive manipulative behaviors by physically handicapped must be dealt with effectively in classrooms. Attitudinal change can best be initiated through providing appropriate models who project warmth, open-mindedness, fairness, and a real concern for each child.

The problem is not only one of children accepting the handicapped Solomon points out that it is also a problem for the professional educator: He states:

> The regular teachers were fearful. Some were repelled. Some were anxious because of feelings of inadequacy. Some provided generous doses of pity but little understanding or acceptance (Solomon, 1977).

■

Being a fairly strong academic student the teachers simply overlooked the idea of homework and allowed the tests to reflect my grades, often more generous with grades than my test performance reflected.

As a student with a mild orthopedic handicap during my Junior High School years, I can certainly relate many direct experiences which illustrate this point. I found that by careful manipulation I could avert most of my school work. Because I was attending a physical rehabilitation program two or three days a week in a neighboring community, I was able to forestall most homework assignments. My school days consisted primarily of taking tests and incidental involvement within the rest of the instructional program. Being a fairly strong academic student the teachers simply overlooked the idea of homework and allowed the tests to reflect my grades, often more generous with grades than my test performance reflected.

As a result I often feel there are voids in my academic training during my junior high school years which handicap my performance yet today. Fortunately, during the ninth grade, I can recall two teachers who maintained an attitude of eager and positive acceptance, yet not only expected but demanded a full effort on my part.

■

. . . all teachers and administrators should have training in both areas of regular and special education.

As a professional educator, I feel strongly that all teachers and administrators should have training in both areas of regular and special education. Only then will there be a balance between realistic expectations from the teachers accompanied by full participation from the handicapped student. Teachers must be made to realize that essentially every act that a person makes is, from his perspective at the time it occurs, the most appropriate response he can make to the stimulus to which he is responding. A student then when misbehaving is doing what seems to give him, at the moment, the greatest degree of psychological comfort (Kindsvatter, 1978).

Teachers often tend to justify inappropriate student performance by imposing a failing grade. What we fail to realize is that the failing grade is often a major obstacle to increase student responsibility, and is frequently manipulated by the handicapped to avoid effort. The handicapped student becomes astute at shifting the responsbility from him/her to the teacher. The student in order to protect his ego, claims he was not given a fair chance. The teacher in turn compromises his conscience and gives a passing or satisfactory grade out of pity or sympathy (Johnson, 1978). The child begins to learn that behavior has no consequences and through manipulation of others, s/he can ignore responsibility and consideration for other persons.

If we are indeed preparing handicapped children to function in the real world, the need for mainstreamed education is critical.

Hopefully, the mandate of P. L. 94-142 requiring that local school districts develop an Individualized Educational Plan for every handicapped child will alleviate many of these past deficiencies. It can serve as a planning system and monitoring device to enable the administrators, teachers, parents and child to work towards certain goals. This development of skills which will enable the handicapped child to function effectively as an independent adult and productive member of society cannot be overemphasized. If we are indeed preparing handicapped children to function in the real world, the need for mainstreamed education is critical. Iris Kizer, principal of the Alexander Graham Bell School for hearing impaired children in Cleveland, Ohio states:

> Better they work it out in the classroom among friends than to get on the job and discover they have these problems (Cole, 1977).

It is impossible to describe appropriate teaching roles for an individual child, as each child is unique and adaptive behaviors will be different for each child. However, there are a few general considerations which teachers may find helpful.

1. Provide experiences in which the child can achieve success. If expectations become unrealistic the teacher does not discipline the child for what he does, but for what he is.
2. Emphasize what the individual can do.
3. Perceive the person's basic self-worth.
4. Allow handicapped person to play an active role in planning and living his life.
5. Value even minor accomplishments, and not necessarily because they will meet or exceed a norm.
6. Realize the visibility of the condition.
7. Provide assistance to disabled without demeaning them.

Responsibility to the Orthopedically Handicapped Student

All individuals grow and develop as a result of experiences, relationships, thoughts and emotions. Virginia Axline states the following:

> The child must first learn self-respect and a sense of dignity that grows out of his increasing self-understanding before he can learn to respect the personalities and rights and differences of others. The child must experience himself as a capable, responsible person in a relationship that tries to communicate to him two basic truths: (1) that no one ever really know as much about any human being's inner world as does the individual himself; (2) that responsible freedom grows and develops from inside the person (1964).

Physically handicapped students must be brought to perceive a basic self-worth. The child must be made to realize the visibility of his/her condition and the fact that, for most physically handicapped, the visibility will affect his/her interactions with other people throughout life. The individual must be made to understand that acceptance is a slow, continual process and if s/he is to be successful it is necessary to play an active role in planning future goals.

Not So Different

It should be stressed that the orthopedically handicapped child is generally not affected in the way he learns. The adjustments necessary are physical rather than educational. There is probably no greater dejection for a handicapped person than to begin to engage in an activity only to have a normal person intrude and do it for him/her. It should be stressed in helping the physically handicapped that patience, rather than assistance, is needed. The school should assume responsibility for providing an environment which allows the orthopedically handicapped to be as independent as possible and to promote freedom of movement and physical activity. In addition to the modifications necessary in the gross physical environment, the teacher should always look for ways to provide aids and devices which can assist the child in functioning independently. Because of the heterogeneity of crippled individuals it is impossible to describe devices appropriate for an individual child.

There is probably no greater dejection for a handicapped person than to begin to engage in an activity only to have a normal person intrude and do it for him/her.

Many compensations can be made by providing the orthopedically handicapped with special equipment which allows them to function independently. Some of the more common items are: (a) book racks for children who cannot hold books; (b) ceiling projectors for children in bed in hospitals and/or homes; (c) electric typewriters; (d) automatic page turners and pencil holders (Kirk, 1972). An effort should be made to secure equipment similar to those listed and also other prosthetic aids for locomotion, life support, personal grooming, communication and household aids. Many such aids are explained and illustrated in Smith, 1975.

Like all children, the crippled have certain hopes and aspirations which affect their behavior. However, because their means of satisfying them are more limited, we must determine ways to help them find realistic ways to meet their needs. Once they meet success the are more likely to be objective toward their physical handicaps and accept their limitations.

Kirk (1972) states the following:

> Because of the child's inability to gain a normal feeling of security and because he has often been over-protected at home, there is a tendency to rely on the protectiveness of other people and to prolong his dependency.

It is far better to work at developing physical devices that will facilitate self-sufficiency than to attempt to meet their needs through assistance. Attitudes towards each child's personality and adjustment is extremely important. We must not only be sensitive to meeting the physical needs, but must also help motivate the child who is depressed and withdrawn, and accept the child who sometimes displays emotional outbursts.

Educators must assume responsibility for the development of the total person. Academic achievements are only part of a total education. Learning to live together, learning how to communicate, discovering attitudes and values, learning acceptable social behavior, and learning to accept others are as important. Most importantly we must be a living example to the student, projecting warmth, open-mindedness, fairness and a real concern for the life of each child.

References

Asheroft, C. S. Handicapped in the regular classroom. *NEA Journal,* November 1967, *56.*

Axline, Virginia M. *Dibs in Search of Self.* New York: Ballantine Books, 1964.

Hill, Mildred G., et al. *The Development and Implementation of a Minimun Objective System in the Hinesburg Elementary School.* Washington, D.C.: Bureau of Education for the Handicapped, January 1975.

Johnson, Christopher. Secondary schools and student responsibility, *Phi Delta Kappan,* January 1978, *59.*

Kindsvatter, Richard. A new look at the dynamics of discipline. *Phi Delta Kappa,* January 1978, 59, 322-325.

Kirk, Samuel A. *Educating Exceptional Children.* Boston: Houghton Mifflin Co., 1972.

May, Waggoner, and Hotte. *Independent Living for the Handicapped and the Elderly.* Boston: Houghton Mifflin Co., 1974.

Mayer, Colleen. *Understanding Young Children: The Handicapped Child in the Normal Pre-school Class.* Anchorage, Alaska: Treatment Center for Crippled Children and Adults, July, 1974.

Miller, Rozelle J., et al. *Teachers' Guide for Exceptional Children and Youths.* Washington, D.C.: Bureau of Education for the Handicapped, May 1975, 47-48.

Pieper, Elizabeth J. Preparing children for a handicapped classmate. *Instructor,* August/September 1974, *84.*

Smith, Robert M., and John T. Neisworth. *The Exceptional Child: A Functional Approach.* New York: McGraw-Hill, 1975, 235-255.

Solomon, Edward L. New York City's prototype school for educating the handicapped, *Phi Delta Kappan*, September 1977, *59*, 7-10.

Adapting Curricula for Handicapped Kindergarten Children

Bennett F. Berhow
Department of Education, University of North Dakota, Grand Forks, North Dakota

The development and implementation of a science curriculum for thirteen handicapped kindergarten students will be described and evaluated in this paper. The purpose of this discussion is to illustrate the successful adaptation of existing science materials, to posit some of the limitations and difficulties and to make recommendations concerning the adaptation of existing science curricula to meet the educational needs of handicapped children.

The planning and teaching summarized in this paper was done by Ms. Debbie Foughty, a senior elementary education student at the University of North Dakota (UND), Grand Forks, North Dakota. Ms. Foughty planned and taught the described sequence to fulfill the required work in an independent study in elementary science that was taught by the author of this paper. Ms. Foughty does not have a very extensive content background in science and chose to undertake the learning task in an effort to improve her science teaching competence.

The author and Ms. Foughty initiated the planning task by discussing the possible functions of the science curriculum in the anticipated program for handicapped kindergarten students. The functional definition of science for the purposes of identifying an instructional sequence focused upon manipulative experiences that emphasized children exploring their world with imagination and curiosity. Discussions of cognitive expectations emphasized using the senses and the development of vocabulary that would help children more precisely communicate their observations of their environment. Resources of science activities to assist in the instructional planning were located in the author's personal library and the university bookstore. The non-science resource materials and instructional materials were located in Sweetwater Elementary School.

. . . the possible functions of the science curriculum in the anticipated program for handicapped kindergarten students.

The science curriculum described in this paper was developed to meet the needs of a very small group of students in a very unique educational circumstance. The conclusions and recommendations offered should be viewed within the framework of these environmental constraints and limitations.

The kindergarten for handicapped children was located in Sweetwater

Elementary School, Devils Lake, North Dakota. Devils Lake is a community of 7,000 people located in central North Dakota and is 100 miles from the University of North Dakota. The public school system has three elementary schools, one junior high school and one high school that serves 2,000 students. Sweetwater Elementary School, with 252 students, is the smallest of the three elementary schools. Kindergarten is not required by state law and the Devils Lake school district, as is typical in North Dakota, does not support a regular kindergarten program for all children. Parents must send their children to private institutions if they desire kindergarten experience for their children. The kindergarten for handicapped children at Sweetwater was financially supported through the school district and served the entire Devils Lake community.

■

All children in Devils Lake are screened for handicaps during the spring preceding their enrollment in first grade.

All children in Devils Lake are screened for handicaps during the spring preceding their enrollment in first grade. This does not occur early enough in the year to permit enrollment in the kindergarten program for handicapped children. Most parents who enrolled their children in this second special kindergarten heard of the program by word-of-mouth and it was the parents who decided if their child should be included in the special kindergarten. Some of the children had handicaps that were diagnosed by professionals; many were placed in the class because parents believed the program was needed by their child.

Five of the children had hearing impairments. One child's impairment was severe enough to require a hearing aide and the child's impairment may be severe enough to require some schooling at the North Dakota School for the Deaf in Devils Lake. The hearing impairment of the other four children was not severe enough to require a hearing aide, but the hearing impairment did seem to have some effect upon speech development.

Three of the children had sight impairments. Two of the children suffered amblyopia that was being treated by a physician and required them to wear patches over an eye. The third child's sight problem, although limiting, was not precisely diagnosed and was not being treated by a physician. The children being treated by a physician have eye-sight that is greatly diminished and the eyes of the child not being treated are apparently lazy.

The other children in the classroom suffered from a multitude of other impairments. Two children were receiving physical therapy because of muscular difficulties. The remainder of the children suffered developmental impairments that were evidenced as poor motor skills and coordination, language impairments and learning disabilities.

Sweetwater Elementary School uses Elementary Science Study (ESS) materials as its science curriculum. Ms. Foughty, who planned and taught the described science curriculum, had used some of the ESS materials and decided to search other resources for appropriate science activities. She wanted an integrated program of art, music, language arts, science, math, and even cooking, and felt that individual activities rather than units were more suited to her needs. A bibliography of resources for science activities is provided with this paper. Other classroom non-science teaching resources and materials, such as the *Peabody Language Kit,* music books, literature books, etc., that were regularly used in the classroom are not listed in the bibliography.

As part of the total learning program design, Ms. Foughty synthesized a set of learning outcomes that were to be achieved through child participation in selected science activities. The cognitive and developmental outcomes, as objectives, are listed below.

1. Interpret sensory stimuli by:

    a. using the senses to describe and identify objects hidden in a sack.

    b. identifying the taste and the name of food when blindfolded.

    c. distinguishing between salt and sugar.

    d. describing the size, color and shape of objects while playing a game.

    e. making sounds using their mouths and selected objects.

2. Demonstrate visual awareness by identifying shapes—square, triangle, circle and rectangle.

3. Demonstrate listening awareness by differentiating sounds as:

    a. loud-soft

    b. high-low

4. Identifying the seasons by:

    a. identifying activities associated with each season.

    b. identifying clothing that is worn during each season.

5. Experience spatial relationships between self and the environment (full to the top, over, under, etc.)

6. Perceive size as an attribute which is both concrete and relative by:

    a. comparing the height of the children.

    b. serializing buttons by size.

7. Recognize the characteristics of liquids by:

   a. describing what way water pours.

   b. identifying objects that float in water.

   c. describing what happens when materials such as salt, flour, food coloring and syrup are added to water.

   d. describing what happens to ice when it gets hot.

8. Identify shapes of circle, square, rectangle and triangle in the environment.

9. Recognize various aspects of weather by:

   a. identifying how a kite flies.

   b. identifying what is melted snow.

10. Group and classify buttons according to attribute identified by the student.

To illustrate the type of science activity used and its integration with other components of the kindergarten instructional program, a specific instructional sequence is provided below. The example instructional sequence is Ms. Foughty's lesson plan for one week which she wrote, taught and sent to the author.

Lesson Plan

General Instructional Objective: *Perceive size as an attribute which is both constant and relative.*

Activity 1: *Compare height of all children. Tape a long piece of paper along the wall, one side touching the floor. Have the children stand, one at a time, with their back to it to be measured. Write each child's name on the line that indicates his height.*

When finished, ask: Are you all the same size? Which ones are shorter? Which ones are taller? Why are some bigger than others? Are older people bigger than children? Why? Will you stop growing taller some day?

I then measure myself on the chart to show that adults are taller. Ask: Do you know some adults taller than I am? Why do some people grow taller than others? Have children arrange themselves from short to tall. Then ask them to reverse the order.

Label objects around the room using terms regarding size.

Activity 2: *Grouping and classifying buttons, to develop skill in observing, grouping and classifying.*

Give each group of two students a handful of assorted buttons and ask them to make two groups that are alike in some way.

> *Next, ask them to reassemble the buttons into three groups. There will be no right or wrong responses. Ask them to explain what they have done.*
>
> *Have them serialize the buttons in a line from small to large.*
>
> *Have them make various shapes using the buttons.*
>
> Activity 3: *Read "The Big Radish" by Maria Robbins and "Big Dog . . . Little Dog" by P. D. Eastman. Read "Tall and Short" poem by Big Bird and Little Bird.*
>
> Activity 4: *Have children make cookies with Cookie Monster again. Have each child only make two cookies—a very large one and a very small one. Discuss.*[1]

The evaluation of the success of the science instructional sequence in the kindergarten program focused upon observing the behavioral changes of the children. Ms. Foughty is trained in classroom observation strategies as a learning evaluation tool. In addition, portions of classes were video-taped and sent to the author for observation. The following discussion of behavioral changes of the children is based upon observational data gathered by Ms. Foughty and the author.

At the beginning of the semester many children exhibited very limited attention spans. They were able to effectively function in a group setting for only a short period of time and they then withdrew from the group activity, both physically and functionally. This was particularly a problem for two of the children. One child would withdraw from the group seeking "mothering" from an adult. The other child would withdraw from the group and engage in physical activity with much jumping, twirling and hand shaking.

■

. . . they became less anxious or concerned about spilling materials on the floor or making a mess on the tables.

There were other behaviors observed that interfered with maximum functioning in a school environment. Many of the children seemed timid and unsure of themselves and needed extensive, detailed directions and close supervision. Many of the children also exhibited some language difficulties. Mispronounced words and incomplete sentences characterized much of their language behavior.

By the end of the semester all of the children were able to complete a science activity without withdrawing from the group. In addition, the children demonstrated an ability and eagerness to initiate and control the processes in which they were engaged. Ms. Foughty was not required to give frequent and detailed directions for completing investigations. This increased self-discipline also seemed to help the students become more relaxed and comfortable when manipulating materials. For example, they became less anxious or concerned about spilling materials on the floor or making a mess on the tables.

---

[1] *Ms. Foughty's complete sequence of planned science lessons is available upon request from Dr. Bennett F. Berhow, Education Building, Room 105, University of North Dakota, University Station 179, Grand Forks, North Dakota, 58202.*

■
Many new words were added to their vocabulary but the most significant change in verbal behavior seemed to have occurred in group activities. The amount of interaction greatly increased with questions being asked and observations being verbalized.

The language development of the children was particularly marked. Many new words were added to their vocabulary but the most significant change in verbal behavior seemed to have occurred in group activities. The amount of interaction greatly increased with questions being asked and observations being verbalized. The amount of verbalization of each child increased and the number of people the children interacted with increased. The interaction increase was noted among the children and between the children and the adults.

Based upon the observations of Ms. Foughty and the author, the following conclusions concerning the success of adapting existing science curricula to meet the educational needs of physically handicapped kindergarten children were formulated:

1. The children enjoyed the science activities and looked forward to their "science time" with great anticipation. "Science time" was the last activity of the school day and the children verbalized an eagerness for the time to begin.

2. The children were able to develop self-discipline skills in a schooling environment that should better their chances for success in first grade. Most of the children will enter a regular first grade classroom the following year.

3. The self-concept of each child was enhanced because the science activities provided every child an opportunity to have success in a school setting.

4. The teacher was able to change from a teaching behavior that controlled all activity to a more facilitative style.

5. Skill development of the children required in the special education guidelines and reports of the teacher of record was achieved by participation in the science activities. Vocabulary and motor skills specifically listed as learning objectives in the special education guidelines were particularly enhanced.

The following conclusions concerning the difficulties of adapting existing science curricula to meet the educational needs of physically handicapped children were formulated:

1. Adaptation requires extensive planning effort by the teacher. This is particularly true when the science curriculum is integrated with the other curricular components of the school program.

2. The mandated curricular time requirements of many state and federal program guidelines for physically handicapped children, particularly in the language arts, make the scheduling of science activi-

ties difficult and not meeting the required time constraints may often endanger program funding.

Based upon an analysis of the conclusions in this paper the author recommeds that:

1. Existing elementary or early childhood science curricula be modified for physically handicapped children and implemented on an experimental basis. Evaluations of such adaptations should primarily focus upon student development, cognitively and attitudinally, and upon observed student response to the curriculum.
2. Support systems be developed to assist teachers in the adaptation process. The effort required to effectively design and implement an elementary or early childhood science program for physically handicapped children probably cannot be expected as part of daily teaching activities required of teachers in typical teaching-learning processes.

Bibliography

Day, B. *Open learning in early childhood.* New York: MacMillan, 1975.

Harlan, J. D. *Science experiments for the early childhood years.* Columbus, Ohio: Charles E. Merrill, 1976.

Munson, H. R. *Science activities with simple things:* Belmont, California: Fearon, 1972.

Playmate magazine.

Project self-discovery. Educational T.V.

Reid, R. W. *Science experiments for the primary grades.* Belmont, California: Fearon, 1962.

Schmidt, V. E., and V. N. Rockcastle. *Teaching science with everyday things.* New York: McGraw-Hill, 1968.

Spencer, Z. A. *150 plus! games and activities for early childhood.* Belmont, California: Fearon, 1976.

Throop, S. *Science for the young child.* Belmont, California: Fearon, 1974.

Laboratory Science and Art for Blind and Deaf Children

Doris E. Hadary
Department of Chemistry,
The American University,
Washington, D.C.

A program of "what can be done"—not only "what should be done"

Introduction

In partial response to the question of the present status of science for physically handicapped students, I offer a description of Project Seefee which was started six years ago at The American University (A.U.) funded by the William T. Grant Foundation. The program went through a process of development, starting in 1971 as a science teacher training program to which in 1972 was added curriculum design and research in adapting science materials for blind and disturbed children. Adapting science materials for the deaf was added in 1975, as well as a related art program. Mainstreaming this program began in 1976. It is presently a program of laboratory science and art used as a vehicle to advance education for blind and deaf children. The project is a small, mainstreamed, multidisciplinary program for handicapped children which combines the inextricable elements of teacher training with emphasis on content and communication, curriculum design and implementation. These are essential elements to the success of any program for the handicapped—and for all children. The interdependence of these elements, I am sure, is recognized by educators, however, it is neglected and exists as fragments of the whole which need pulling together.

The present project consists of a total population of 200 ordinary children of the Horace Mann Elementary School in Washington, D.C. Blind, deaf and disturbed pupils are bused into the school four afternoons a week from nearby school districts for mainstreamed laboratory science and art classes in grades Kindergarten to 6. The handicapped children work side by side with the ordinary elementary school children.

Science and Art Curriculum

The curriculum consists of adapted science experiments and related art experiences which are based on the major science curricula being used today in elementary schools nationally and internationally.

As a result of my participation in the development of science programs for elementary schools, I have had the opportunity for many years to make contributions to and make comprehensive reviews of many of the major science curricula being used today in elementary schools, in schools for blind children, for deaf children, and disturbed children. It is from these programs with the cooperation of Dr. Herbert Thier of Projects Science Activities for the Visually Impaired, SAVI, and Adapting Science Materials for the Blind, ASMB, and various faculties from schools for the deaf that I have adapted science and art experiences making Project Seefee a program appropriate to the needs of hearing impaired and visually impaired students. The hearing and sighted children receive reciprocal benefits from the experience—academically, socially and spiritually.

. . . adapted science and art experiences making Project Seefee a program appropriate to the needs of hearing impaired and visually impaired students. The hearing and sighted children receive reciprocal benefits from the experience—academically, socially and spiritually.

We have designed, adapted, implemented, and tested approximately 150 science lessons with matching art lessons from the following:

Biological Sciences

organisms
life cycles
ecosystems

Physical Sciences

material objects
experimenting with common objects
gases

Interactions and Systems

"inventing" the interaction concept
evidence of interaction
"inventing" the systems concept
systems in the classroom
gathering evidence through various senses
exploring pulleys
comparing pulley systems
"inventing" interaction-at-a-distance
magnetic interaction
electric circuit puzzles

Subsystems and Variables

solutions and mixtures
objects that can close a circuit
separating a powdered mixture
"inventing" the subsystems concept
"inventing" the solutions concept—filtering crystals
separating mixtures
properties of freon and water
whirly bird variables—controlling variables

Energy Sources

temperatures of water and ice systems
"inventing" histograms
"inventing" energy sources and receivers
transferring energy

Experiments on these topics were developed for gifted youngsters enrolled in the Enrichment Science Laboratory at The American University:

energy transfer
water wheels
energy chain concept
Archimedes principal
heart sounds and pulse
properties of light: refraction, absorption, reflection
properties of sound: vibrations, frequency, pitch
effects of string tension
effects of change in length of string
the resonator
the bridge
media for carrying sound
periodic motion
propagation of sound waves
medium through which sound propagates
vibration of the gong
properties of air: weights and elasticity
structure of the ear as an organ
frequency limits of the ear
coupling the vibrating string to a resonating box
vibration from the string to the body of the violin
dampening the resonator
vibrating column of air as origin musical tone
thermodynamics—experiments to measure directly the mechanical equivalent of heat

Teacher Training

Our training program addresses itself to the new image the elementary school teacher must take on in the "real world" of the educator of children today. The teacher must get an appreciation of science as a powerful tool of communication with children and among children, of science as a means for development of self-esteem of science as a way of the child's relating, understanding, living in one's environment, of science as a means of compensating for a sensual lack, of science as a means of making a handicapped child feel "complete". The teacher must be sensitized to the different needs of the handicapped children in general, and as they relate to the learning of science through the experiential approach. To accomplish this goal the pre-service program for our future teachers is content-oriented.

The teacher must get an appreciation of science as a powerful tool of communication with children and among children, of science as a means for development of self-esteem . . .

1. An interdisciplinary laboratory course enveloping chemistry, physics, and biology is the base of the training.

The teacher must "live" the experience of the experiential approach, the scientific method of problem solving, to learn the vocabulary that allows understanding of scientific concepts, and, above all, experience the excitement of discovering and understanding the concepts of science—to be able to effectively communicate with the handicapped child through science.

It is absolutely essential that teacher training with emphasis on science content must go hand in hand with learning skills of communicating with the handicapped child through subject matter.

It is absolutely essential that teacher training with emphasis on science content must go hand in hand with learning skills of communicating with the handicapped child through subject matter. In order for the teacher to be able to deal with problems of communication with the handicapped child s/he must be knowledgeable in the philosophy of and science content involved in the experiential laboratory approach. This is extremely important since our experience shows that the approach provides a successful means for dealing with problems of all levels of communication that almost all handicapped children have.

The program prepares teachers to guarantee the handicapped child improved science education which is essential as a foundation for upper level science education and career preparation.

The teacher learns to adapt laboratory materials in accordance with the sensory channel preference of each child. In our practicum s/he does so by actual experience with the child—always testing, revising, and adding better ways of communicating to all the children—being constantly aware of learning content, learning rates, and learning styles. Our teachers learn Braille and sign language.

2. Our teachers take part in seminars once every three weeks with psychologists, specialists in working with blind, deaf, and disturbed children.

3. Lessons in Braille, sign language (total communication), and Que speech are given once a week.

4. Research teams work with research directors and graduate students in designing and making studies of evaluation of the program. (See references.)

5. Practicum in teaching science to ordinary children.
   Practicum in teaching science to blind children.
   Practicum in teaching science to deaf children.

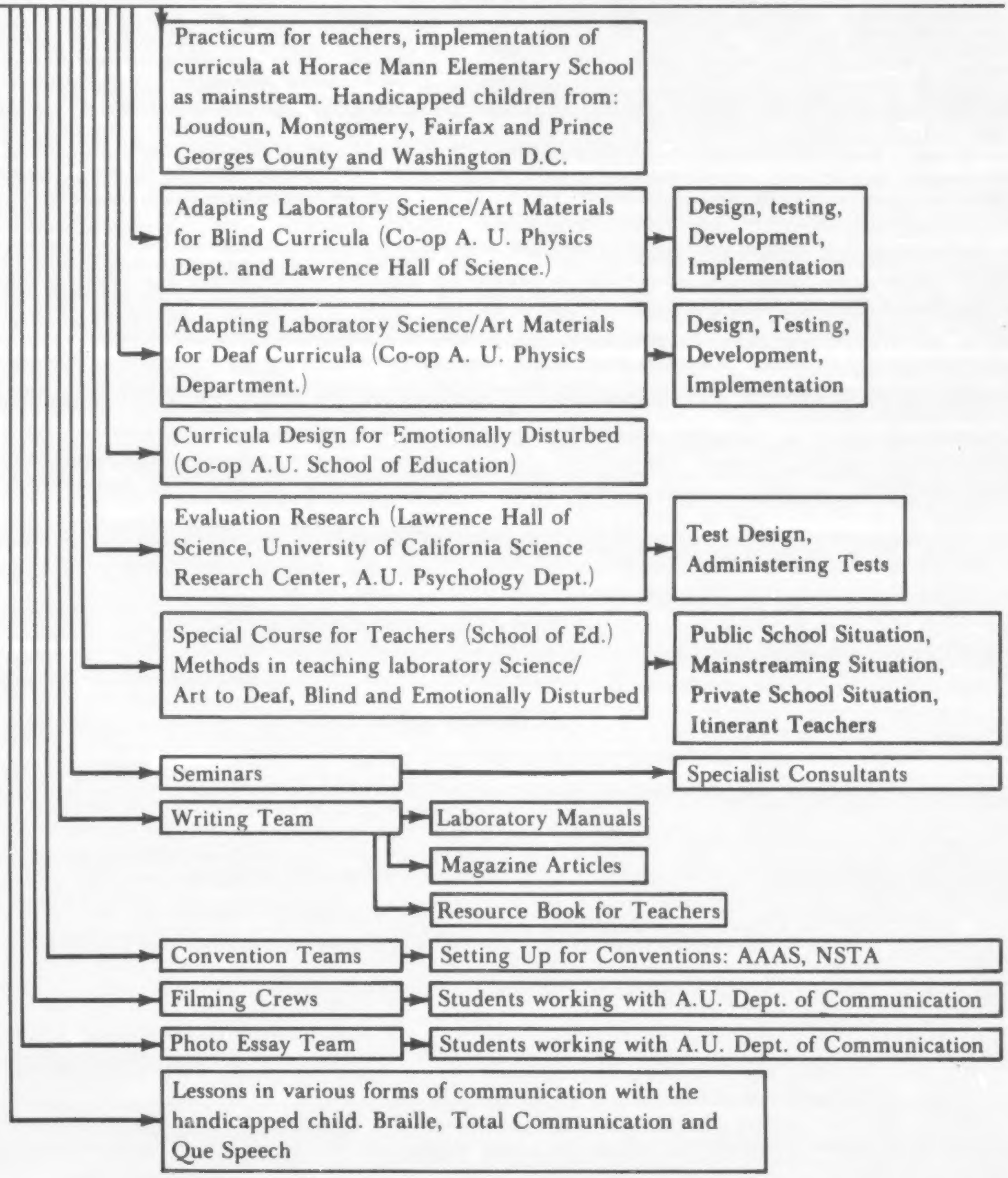
6. Laboratory sessions in performing elementary school science experiments. Learning use of adapted materials. Discussion and practice of teaching strategies.

The following is a flow chart summary of the pre-service training curriculum.

Advancing Education for the Blind, Deaf, and Emotionally Disturbed, through Laboratory Science/Art Oriented Programs

---

Required Basic Background for teachers
Science as vehicle
*Lecture-Discussion: Chemistry, Physics, Biology, Math
*Laboratory Experiments-Discovery Projects: Chemistry, Physics, Biology, Math
*Laboratory Activities-Experiment: Elementary School Science Programs
SAPA, ESS, SCIS, COPES, OTHERS.



Practicum for teachers, implementation of curricula at Horace Mann Elementary School as mainstream. Handicapped children from: Loudoun, Montgomery, Fairfax and Prince Georges County and Washington D.C.

Adapting Laboratory Science/Art Materials for Blind Curricula (Co-op A. U. Physics Dept. and Lawrence Hall of Science.) → Design, testing, Development, Implementation

Adapting Laboratory Science/Art Materials for Deaf Curricula (Co-op A. U. Physics Department.) → Design, Testing, Development, Implementation

Curricula Design for Emotionally Disturbed (Co-op A.U. School of Education)

Evaluation Research (Lawrence Hall of Science, University of California Science Research Center, A.U. Psychology Dept.) → Test Design, Administering Tests

Special Course for Teachers (School of Ed.) Methods in teaching laboratory Science/ Art to Deaf, Blind and Emotionally Disturbed → Public School Situation, Mainstreaming Situation, Private School Situation, Itinerant Teachers

Seminars → Specialist Consultants

Writing Team → Laboratory Manuals
Writing Team → Magazine Articles
Writing Team → Resource Book for Teachers

Convention Teams → Setting Up for Conventions: AAAS, NSTA

Filming Crews → Students working with A.U. Dept. of Communication

Photo Essay Team → Students working with A.U. Dept. of Communication

Lessons in various forms of communication with the handicapped child. Braille, Total Communication and Que Speech

Research

I should like to briefly mention some results of the most recent research pertinent to mainstreaming deaf children in science classes in our program.

Three forms of evidence suggest the advantages of the mainstream situation.

1. Results of cognitive tests show no difference in gains between resource students and mainstream students.

2. Results of observation of the performance of resource and mainstream students indicate that in both situations students can engage in interactive learning experiences, although in the resource setting there are more opportunities for discussion and reporting of results verbally, whereas in the mainstream situation there are more opportunities for working with apparatus.

3. Results of the questionnaires administered to non-handicapped students in a mainstream situation indicate that students, in general, were very favorable about the presence of the handicapped children in their classes and, in fact, very frequently pointed out the advantages of having the handicapped children for their own educational benefit.

In addition, only the youngest students were concerned about the presence of handicapped children, and their concern appeared to stem more from their lack of familiarity with handicapped children than from any specific aspect of the instructional program. Thus, it is likely that the concerns expressed by these second grade children would be ameliorated over time.

Clearly, mainstreaming can be effective. In addition, deaf students are likely to feel more positive about themselves when they find they can learn along with regular peers. It is likely that regular students will be more accepting of handicapped students when they all learn together. Many questions require further research including the impact of having handicapped students in class on the cognitive gains of regular students, and characteristics of teacher training necessary to achieve a successful mainstream class.

References

Hadary, Doris E. et. al. "Breaking Sound Barriers for the Deaf Child." *Science and Children* 14:33, Nov./Dec., 1976.

Hadary, Doris E. et al. "Interaction and Creation Through Laboratory Science and Art for Special Children." *Science and Children* 13:31-22, March, 1976.

Hadary, Doris E. et al. "Picking Up Good Vibrations From Science for the Handicapped." *The Science Teacher* 42:12-13, December, 1975.

Hadary, Doris E. and Susan Cohen. *Laboratory Science and Art for Blind, Deaf and Emotionally Disturbed Children: A Mainstream Approach.* Baltimore, Md.: University Park Press, 1978.

Hadary, Doris E. and Nicholas J. Long. "Twenty-Five Field Tested Science Lessons for Elementary Age Pupils With Special Needs." Mimeographed, 1975. The American University, Washington, D.C.

Hadary, Doris E., Nicholas J. Long, and William Griffin. "A Research Evaluation of Specialized American Curriculum for Emotionally Disturbed Pupils in Elementary School." Mimeographed, 1973. The American University, Washington, D.C.

Linn, Marcia C., Doris E. Hadary, Richard Rosenberg, and Robert Haushalter. "Evaluation of Ideal Mainstream and Resource Programs to Teach Science to Deaf Children." Paper to be presented 1978 AERA Annual Meeting. (To be published.)

Long, Nicholas J. and Richard Rosenberg. "A Sociometric Study of Mainstreaming Handicapped Children in Science Classes." (To be published.)

Struve, Nancy L., Doris E. Hadary, Herbert D. Thier, and Marcia C. Linn. "The Effects of an Experiential Science Curriculum for the Visually Impaired on Course Objectives and Manipulative Skills." *Education of the Visually Handicapped* 7 (1):9, March, 1975. The Official Publication of the Association for Education of the Visually Handicapped.

Struve, Nancy L. et al. "The Effect of an Experiential Science Curriculum for the Visually Impaired on Course Objectives and Manipulative Skills." *Exceptional Children,* April, 1974, p. 516.

Thier, Herbert D. and Doris E. Hadary. "We Can Do It, Too." *Science and Children* 11:7-9, December, 1973.

Benefits from Science Education for the Handicapped

Ronald Schnur and Carl Berger
Midwest Trial Center, University of Michigan, Ann Arbor, Michigan

The two topics of science education and special education are often thought of in terms of the contributions from science education to special education. However, unexpected outcomes from trials of a new science curriculum for the handicapped have shown that the benefits of disseminating new activities can flow just as strongly in the opposite direction, from special education to regular classroom education. This is important because the dissemination of new science activities to special education resource rooms can provide a remarkably effective way to improve science teaching in regular classrooms, as well as having the benefits of enabling special students to work in a truly least restrictive environment.

■

benefits of disseminating new activities can flow just as strongly in the opposite direction from special education to regular classroom education.

The experiences presented in this paper relate to the trial teaching of SAVI (Science Activities for the Visually Impaired), a hands-on elementary school science program under development at the Lawrence Hall of Science in Berkeley, California, under a grant from the Bureau of Education for the Handicapped, U.S. Office of Education. These science activities are undergoing formative evaluation in five trial centers throughout the United States using the varying settings in which visually handicapped students are educated, including residential schools, special classes and special resource rooms in public schools, and in regular classrooms containing mainstreamed visually impaired students. The observations in this paper come from the results of trials in four school districts associated with the Midwest Trial Center for SAVI at The University of Michigan. While SAVI is being successfully used with small groups in each of these settings, the special interest of this paper is how SAVI's use in elementary school resource rooms and special classrooms has affected regular classrooms, both those with mainstreamed special students and those without special students.

The introduction of SAVI to special classrooms quickly revealed important differences in teaching processes between special and regular classrooms. This introduction was accomplished with astonishing readiness considering the demands of discovery-oriented science curricula and the difficulties usually encountered in dissemination. A close look at the classrooms revealed an important reason for the ease in training special teachers in open science approaches—that much of ordinary special education practice is identical in process to open science education. For instance, notice the similarity of the principles of Berthold Lowenfeld[1] on teaching the visually handicapped with the principles of discover-oriented science teaching:

1. *Individualization*—classes should be oriented to the differences between children and the ways they learn, not towards finding the least common denominator between children. This implies that educational work should be carried out in small group classes or small groups.

2. *Concreteness*—if the child is to understand his world, he must have opportunities for manipulation and exploration, especially in the case of blind children by touch.

3. *Teaching by units*—in the absence of vision, the "unit plan of instruction offers the best opportunity to place the necessary organization of experience."

4. *Securing experiences*—"the teacher of blind children must provide them with opportunities for experiences which they cannot gain on their own."

5. *Self-activity*—the blind child learns about his environment by initiating activities that lead to coping and mastery.

Also, compare the following important characteristics of special education teachers with desirable characteristics in activity-oriented science teaching:

1. Teachers of the handicapped are quite used to using extensive manipulative materials and are not disturbed when such materials are used to the point of loss or breakage.

2. Teachers of handicapped students are very willing to communicate successes of handicapped students to other teachers.

3. It is often easy for regular classroom teachers to visit handicapped students while they are working on science activities. Such classrooms often have many visitors while involved in multiple activities.

4. Teachers of the handicapped are used to modifying and adapting materials.

5. Such teachers typically rely on systematic assessment to determine age-level expectancies in various areas of learning.

---

[1] *Lowenfeld, B.* Our Blind Children: Growing and Learning with Them. *Third Edition, Springfield, IL: Thomas, 1971*

6. Such teachers are used to exploring a wide variety of curricular options.

While it is clear that these principles are important for non-handicapped as well as handicapped children, ordinary science teaching often runs counter to them for several reasons. First, teachers are often reluctant to try new materials. Second, the emphasis on process is not familiar to teachers as they have been taught science. Third, the emphasis on multiple lines of inquiry often makes teachers uncomfortable. Last, activity-oriented approaches are difficult for teachers to acquire without the opportunity for first-hand training and observation.

■

But quite unexpectedly, we found that regular classroom teachers were not only observing the special teachers but were even bootlegging SAVI materials for use in their regular classrooms with non-handicapped children.

But quite unexpectedly, we found that regular classroom teachers were not only observing the special teachers but were even bootlegging SAVI materials for use in their regular classrooms with non-handicapped children. In effect, special education teachers were serving as highly visible and accessible models for regular teachers and the special classroom had become an informal in-house materials and demonstration center.

Perhaps the most important part of this transfer of skills was in the dissemination of process skills such as grouping and individualization. These process skills are among the chief difficulties faced by regular teachers in using hands-on science activities that require more time, organization, and energy than textbook lessons. Special education teachers are forced to deal with great differences between students and have become experts in individualization, rotating activities, managing small groups, and in using aides and volunteers. These skills are not easily learned but are invaluable in using science curricula that demand time for individual exploration. Special education teachers who are used to dealing with a need for student exploration and manipulation, are valuable models for regular teachers.

There are several factors that can promote such cooperation. First, the activities themselves must be appropriate and appealing for teachers as well as for students. They should be designed to be used very flexibly in order to match widely differing developmental levels of students. Second, the training of teachers must be carried out in the same mode as the desired teaching. In SAVI, for instance, the teachers are trained using plenty of hands-on experience, guided discovery, attention to individual teachers' characteristics and needs, and with opportunity for initiative and innovation. Third, materials are provided to teachers even though individual items might be less expensive locally. Easily available items function as a starter. Once teachers become more comfortable with an open approach, ordinary materials are drawn into the activities. Last, attention must be paid to such organizational issues as sanctioning the entry of new methods, released time for training, and clear role understanding between special and regular teachers.

If these requirements are met, there are advantages beyond the informal, on-site science training of regular teachers that has been discussed. For instance, the education of the special students is improved; not only by content acquisition, but also by involvement in the process of science. This process, emphasizing problem-solving, experimentation, hypothesis-building, and innovation, represents a general way of thinking that is important for handicapped children as they grow up. Of course, this holds equally true for non-handicapped children.

Second, interaction is improved between special teachers and regular teachers. Cooperating in the area of science may promote cooperation in other areas on the same sort of informal, one-to-one basis of mutual benefit.

Third, interaction and perceptions between handicapped and non-handicapped students may be improved, just as between the teachers of these groups. This is especially likely if cooperation between teachers includes interaction between special and regular students as well.

An especially illuminating example of how science education for the handicapped can benefit regular education is the mainstreaming of visually handicapped children into regular elementary school classrooms. For science education this situation raises the question of the handicapped child's use of special versus regular curricula. On one hand, the use of regular science activities is considered nonstigmatizing and a mark of successful integration. On the other hand, the use of special materials may lead to better learning.

In SAVI, training special resource room teachers would not have provided a complete answer for these children in regular classrooms. Instead, it would have led to the use of a double science curriculum for the child—special materials in the resource room, and regular materials in the classroom. In addition, teacher roles would have been changed since the traditional division of educational responsibility is for the regular classroom teacher to concentrate on academic content while the resource room teacher concentrates on special skills.

But SAVI was not used in this manner. Instead, the enthusiasm of the special teachers and students carried the new science activities into the regular classroom. The regular teacher and the special teacher jointly used SAVI with all students, both handicapped and non-handicapped, in the regular classroom. In other words, the teachers were using the reverse of the conventional classroom strategy with handicapped students. Rather than adapting regular science materials for handicapped students, "special" science materials were being used with all students. This unique approach was possible because the special teacher's skills translated so readily to activity-oriented science learning and because the special teacher's example induced the regular teacher to initiate more open teaching. The group aspects of using process-oriented activities also allowed participation of handicapped and non-handicapped students on an equal basis, promoting interaction and positive regard.

■

Rather than adapting regular science materials for handicapped students, "special" science materials were being used with all students.

In conclusion, we have seen that science education for the handicapped can carry important benefits for regular education. Much of special education practice is strikingly similar to that of the text of contemporary science education. Special education teachers can serve as acceptable and accessible models for regular classroom teachers. The resulting cooperation can benefit all students and teachers in ways that extend beyond science learning.

Mainstreaming Physically Handicapped Students

Debbi Swazuk
Program in Rehabilitation Counseling, University of Pittsburgh, Pittsburgh, Pennsylvania

The topic of mainstreaming has been in the limelight for many months. Due to the recent passage of laws which give physically handicapped children the right to receive an education in the least restrictive setting available, mainstreaming has been forced upon the public. This pressure from the government has taken too long to materialize. Unfortunately, for years physically handicapped students have been subjected to segregation in "special schools" where they often received inadequate education, especially in science. Since this working conference is on science education for handicapped students, I would like to direct my attention to what I believe are the problems, solutions, and benefits of mainstreaming physically handicapped chidren into the academic field of science.

I view mainstreaming as a desirable alternative to segregated special education settings, which I believe hinder more than facilitate science education. I specifically refer to the special education teachers whose degrees enable them to touch lightly upon all the academic subjects, but not to provide intensive instruction in particular subjects unless a certain subject is a favorite. In addition, the student is usually faced with minimal, if not totally absent, lab equipment and space, and with inadequate learning conditions.

. . . the special education teachers whose degrees enable them to touch lightly upon all the academic subjects, but not to provide intensive instruction in particular subjects . . .

As welcome as mainstreaming is, it nevertheless poses problems for all involved. As a consequence of long established myths, many believe that the handicapped student cannot function physically in scientific fields. The physically handicapped student may in fact be spastic, have weakness in the hands, and lack coordination and control. This is why they are labelled physically handicapped. However, fields such as Occupational Therapy can help in developing devices and other means to enable the student to overcome physical barriers, and vocational counselors can help pave the way for emotional adjustment and act as go betweens when difficulties arise.

It is unfortunate that society has taken so long to accept the handicapped individual as an equal, as it leaves the teacher who is faced for the first time with a physically handicapped child unprepared to cope emotionally or

---

**The preparation of this paper was supported in part by a grant from the National Science Foundation.*

educationally. The crux of the problem for the teacher is facing the situation and dealing with his or her own emotional reactions. This must occur before any successful mainstreaming can begin. Initially, the teacher may experience a feeling of inadequacy due to a lack of familiarity with the student's disability and not knowing what to expect with regard to the child's strengths and limitations (a child's records may not always give an adequate description, for example, the report might say "needs cuff for handling pencils and can write for ten minutes," but that may mean 10 minutes with a 10 minute rest period, followed by resumption of writing for another 10 minutes). Other factors include how much time the teacher has had for preparation before the student's arrival, what kind of inservice training the teacher has received, how serious the disability is, and the extent to which the child's mobility is impaired.

The problem of lack of information, combined with the teacher's own nervousness about the on-coming situation, can easily compound the teacher's feelings of inadequacy. Teachers may be afraid of physically or emotionally "hurting" the student while teaching. Since they do not understand the full extent of the disability, they don't know what limitation may exist. Also, there is the ever present question of how the student reacts to his own disability, especially if it is newly acquired due to accident or recently diagnosed disease. Teachers also run the risk of embarrassing the child or hurting his feelings. This can cause tension in the classroom and hinder the learning process for all concerned. Such situations can become quite dangerous emotionally if not dealt with properly.

Since it is easier to learn and teach if the working relationship is sound, overcoming feelings of inadequacy and fear is a priority. If they are permitted to mushroom and become threatening, and the teacher feels s/he is not being assisted in dealing properly with the situation of mainstreaming the physically handicapped child, anger may develop among all involved—school personnel, parents, and last, but foremost, the handicapped child and his fellow classmates. The teacher begins to feel the school has carelessly thrust him into an unreasonable situation that he cannot adequately handle. I believe the teacher'as anger at the school, the parents, and the child is justifiable if there is not substantial information about the child, the child's parents, and their emotional and physical ability to handle the situation and consultation is not arranged before mainstreaming begins.

■

. . . the teacher's anger at the school, the parents, and the child is justifiable if there is not substantial information about the child, the child's parents, and their emotional and physical ability to handle the situation and consultation is not arranged before mainstreaming begins.

Once parents, children and teachers are on a consultation basis with each other and doctors and other professionals are involved, the mainstreaming process will begin to prosper. Informal meetings between the teacher and the parents and students prior to the student's arrival in the class would relieve tensions for both and prepare rather than shock the system. The teacher can become acquainted with the child, his limitations and strengths, develop familiarity with the disability, and make any physical changes needed in the classroom before the first day of classes. There are always changes made during the course of the semester, but the physically disabled student will not feel as alienated when changes are gradually made as situations arise and will be more comfortable if changes are already established in the classroom before his arrival. As time goes on the teacher, physically handicapped student, and his peers, with the help of consultants, can work together and find solutions to the problems they experience.

If the school provides the teacher with orientation before the arrival of the handicapped student, involving vital medical and psychological information on the disability the student has, as well as information about resource personnel and programs that may be utilized, the teacher's fears may be alleviated. I believe a colloquium style discussion would help the participants explore their feelings about the situation, share previous experiences with the disabled, and find possible solutions to old and new problems. Through such an exchange of information, all can benefit.

Another major problem teachers experience is discipline. It is easy for them to feel sorry for disabled students and give them more freedom to misbehave than the nondisabled students. This can breed contempt and jealousy among the student's non-handicapped peers. This desire to compensate for the student's physical handicap with more freedom in class must be overcome because the potential damage surely surpasses the benefits.

Of great importance in teaching any student, and especially the physically handicapped, is maintaining humor. Humor is something that can't be taught or learned through orientation; it just has to come from within. But it needs to be there for the teacher to get through the many frustrating situations that he or she will face when mainstreaming the physically handicapped. There will be times when awkward situations will develop and the devices used to overcome problems backfire. If the situation calls for a laugh, everyone should feel free to express it. I can't express enough that everything cannot be taken seriously.

When the physically handicapped are mainstreamed into science classes, it is not only the teacher who is confronted by problems. Non-physically handicapped students are also faced with a lot of new experiences when the disabled are included in their classes. Some of these experiences may seem overwhelming to the non-handicapped students. First, they may need to overcome their reaction to the outward differences between some physically handicapped and themselves. Sometimes these differences can be quite grotesque by society's standards, and they may be frightening and revolting to the non-handicapped. These students need to be given time to cope with the physical differences in their peer. They need time to realize that their peer may look different, but that basically, the student is the same as them, with similar hobbies, likes, and dislikes, surprising as it may be to the "sheltered" non-disabled.

■

They need time to realize that their peer may look different, but that basically, the student is the same as them, with similar hobbies, likes, and dislikes, surprising as it may be to the "sheltered" non-disabled.

To help facilitate overcoming reactions to physical differences, it would be beneficial to all concerned to have a student orientation as well as orientation for teachers. Ideally, this orientation would occur before the students' first day, if the mainstreaming takes place after the beginning of the new school year. The handicapped student could come in and everyone could get better acquainted. The students could discuss their own interests, and explain to the new student what they've been learning in class. Also during this time the teacher could explain what is expected of the students in the class, for example doing an experiment each week. This time would be excellent for explaining limitations that will occur in the science classroom and finding solutions to problems. For example, the student may have weakness or spasticity in the upper extremities or a sensory handicap and may need to borrow someone's notes or have help in doing experiments. The teacher might assign all the students, including the new one, to think of some alternatives for doing assignments, experiments, and so on. The teacher could also ask for volunteers to help the student when needed. Through such a student orientation, the awkwardness that is experienced by new handicapped students can be eased.

Great emphasis must be placed upon helping the student overcome their fear of hurting their physically handicapped peer. They must realize that we don't break that easily, and that if the student feels there is a danger of being injured, he will voice it to the others. I emphatically feel it is the disabled student's job to be frank and open about the disability and its limitations. If the child learns early, as trite as it may seem, that "honesty is the best policy," he will have a better chance of being accepted for who he is, a person who happens to have a disability.

Another reaction non-physically handicapped students may show is testing the new student through ribbing and hazing. They want to see if their peer will fight back, and if he has spunk. Like all children, they want to know if this new student likes to be kidded. If feel this is good because it enables the handicapped child to interact naturally with his peers and enables all to become more at ease. The students are in school not only to receive a sound science education, but to learn about human nature, to better understand themselves through interaction with others, and to learn how to get along with others. But I would like to also stress that the teacher should be ready to intervene if it appears that the other students are becoming cruel or that the handicapped child is not able to handle the situation.

Now I would like to discuss the handicapped student's reaction to being mainstreamed. The student will be as nervous as any new student, but his anxiety may be compounded by his true "differences." He doesn't know how the other students will react to his disability. The disabled student may also be embarrassed by the disability if it has aspects that are not socially accepted, such as the drooling that cerebral palsied children often exhibit or occasional incontinence caused by certain conditions. In such instances, I suggest that the student merely be helped to get the situation under control as well as possible. He might like to help explain it to the class, so that the others will understand that it is beyond the student's control and learn to accept him for who he is.

The handicapped student may also experience a fear of failure. This is prevalent among handicapped students who have gone to "special schools" where they live a rather sheltered existence. There is very little threat of failure there, and competition is practically nil. This is one of the worst aspects of the special school system. The child doesn't learn how to handle competition until he goes to college, thus making the transition from a special school to college an exceedingly difficult task.

■

. . . the quality of science education is much better in a regular school setting where the child is usually taught by a teacher who has expertise in science . . .

This lack of competition in special schools is another reason why mainstreaming is essential. Furthermore, the quality of science education is much better in a regular school setting where the child is usually taught by a teacher who has expertise in science rather than a degree in special education. The child's fear of failure is quite real to him, and failure becomes more probable the longer the schools wait to do mainstreaming. As it is now, very few physically handicapped are academically equipped to go into one of the natural or physical sciences if they have attended special schools.

■

By helping the student develop the skills to perform in a science course, the teacher can develop his independence.

A major result of mainstreaming can be an increase in the handicapped student's independence. By helping the student develop the skills to perform in a science course, the teacher can develop his independence. This can be achieved through low cost environmental changes and the use of helping devices in the labs. For example, an arm-raising device has recently been invented by John Paulton, a student at Rensselaer Polytechnic Institute, to help a biology student stricken with muscular dystrophy. By just using his fingers to operate a switch which controls the arm-raising device, the student is able to raise his arm to pour liquids in the laboratory. As a result of this invention, the student will be better able to actualize his hope of becoming a physician. Architectural barriers in the science classroom can be overwhelming to the handicapped student, but there are easy solutions to these otherwise catastrophic problems. For example, students who are confined to wheelchairs find it almost impossible to use the regular-size lab tables, since they are much too high. This problem can be overcome by the use of portable ramps that the student can wheel up and sit upon in his wheelchair on a platform equal with the table, or by use of a hydraulic pump action to heighten or lower tables.

■

The buddy system can also be used to enhance the handicapped student's ability to perform in science courses.

The buddy system can also be used to enhance the handicapped student's ability to perform in science courses. One problem the physically handicapped student may encounter is weakness or spasticity of the upper extremities which limits his ability to do class assignments. This difficulty can be overcome by pairing the handicapped student with a non-handicapped peer so that they can do experiments together. The buddy system also works well with the sensory handicapped. The blind student can have the science experiment explained by his partner, while the deaf student can stand opposite of a hearing student to follow each step. Since the deaf will have difficulty reading lips and doing the experiment simultaneously, they need only to follow their partner who has stationed himself opposite to complete the assignment and understand the process. In addition, all the disabled could use the buddy system to supplement their class notes.

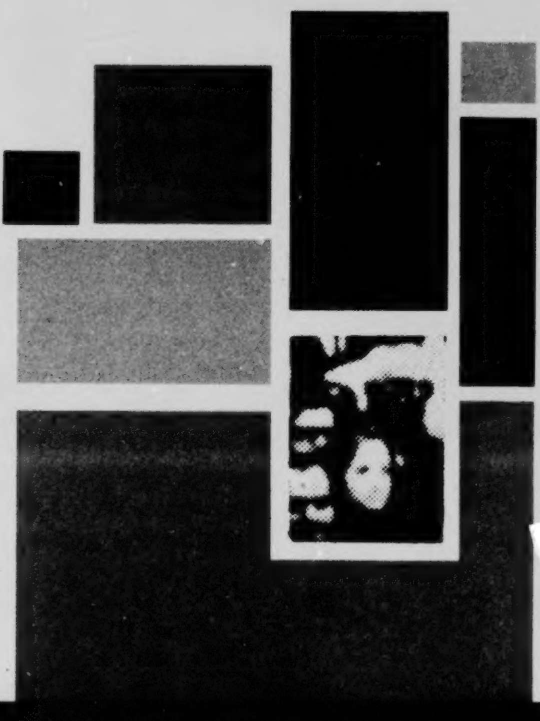
Another method that could be utilized, especially with the deaf, is to hand out an outline of the experimental procedure the day before the class.

This way the student need only glance at the outline to follow the teacher. Another helping device that could be utilized for the blind, particularly in biology classes, would be to supplement their inability to see the various parts of an animal by using a plastic model of the animal's internal organs. This would be similar to models of the human brain that are presently used in science classes. The blind student would be able to run his fingers over the model and thus comprehend more fully what the others are seeing through dissection. These are just a few practices that would aid in teaching science to the physically handicapped. Solutions to the problems handicapped students face can be found if a little time, effort, and usually a minimal amount of money are invested.

Everyone can benefit from mainstreaming physically handicapped students into science classes in regular schools. Those involved can learn to accept others for who they are. Mainstreaming tremendously reduces the stigma of being handicapped and closes the perceived gap between the handicapped and the nonhandicapped, once both groups realize that the differences are quite minimal. After the handicapped student has been in a class for awhile, the teacher and the other students realize that the handicapped don't want or need a lot of extra help. The handicapped want to achieve as much independence as possible. and will let others know their limitations. Through all of this, everyone is able to develop interaction skills in a variety of situations with a variety of people. The primary reason for mainstreaming is that it enables the handicapped to learn in a competitive atmosphere which prepares them to function better in our competitively oriented world. In addition, it allows them to receive a more adequate science education and possibly to choose a science career. Mainstreaming of the physically handicapped is essential to open the doors to a career in science that have been shut against them for too many years.

4

Resources for Teachers/Schools



4

Resources for Teachers/Schools

Introduction

The first time science teachers are suddenly faced with the prospect of having a physically handicapped student in their classes they ask themselves, "What should or can I do?" This chapter identifies some sources from which teachers can seek assistance.

The bibliography includes general references as well as specific references for the auditory, orthopedic and visually handicapped and for extending the science program beyond the classroom. Addresses are given for organizations and agencies which teachers may contact for general or specific kinds of information. Nine professional associations which have an interest in science education are identified. Two of these associations are solely concerned with the area of science and the handicapped. There are two lists of journals: one list contains science education journals, and the second list identifies journals which publish information concerning the physically handicapped. Selected national projects that relate to science education and the physically handicapped are listed.

106

Science Education and the Physically Handicapped: Bibliography

A. Science for Everyone: General References

Achievement. Miami, Florida. Boosters of Achievement, Inc., 1979.

Access to Science. Washington, D.C.: American Association for the Advancement of Science, 1977.

Barrier Free Meetings. American Association for the Advancement of Science, Washington, D.C. 1977.

Brown, Dean. "Helping Handicapped Youngsters Learn Science by Doing," Rowe, Mary Budd. *What Research Says to the Science Teacher, Vol 2.* Washington, D.C.: National Science Teachers Association, 1979.

Davis, Cheryl A. and Martha R. Redden. "Achievement in Biology: An Introduction to Handicapped Biologists," *American Biology Teacher,* 40:175-178, 190, March, 1978.

Faul, Carol. "Geology as a Career for the Disabled," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman Washington, D.C.: National Science Teachers Association, 150-153, 1978.

Hadary, Doris E. and Susan H. Cohen. *Laboratory Science and Art for Blind, Deaf, and Emotionally Disturbed Children.* Baltimore: University Park Press, 1978.

Hegg, Don. "The Hearing Dog Program," *Pure-Bred Dogs American Kennel Gazette.* New York, 94:6, 24-25, 50-53, June, 1977.

Hoffman, Edward, Terry West and Percy Bates. "Exceptional Children in Intermediate and Secondary Science Programs: A Teacher Survey," *Science Education,* 62:11-17, January-March, 1978.

Hofman, Helenmarie (ed.). *A Working Conference on Science Education for Handicapped Students.* Washington, D.C.: National Science Teachers Association, U.S. Educational Resources Information Center, ERIC Document, SE 025 177, 1978.

"Opening Doors for Handicapped Youth," *The Science Teacher.* 45:24, October, 1978.

Owens, Janette A. and others. *Resource Directory of Handicapped Scientists.* Washington, D.C.: American Association for the Advancement of Science, 1978.

Powers, Linda. "Science and Art in Mainstream Education: Toward the Normalization of the Handicapped Child," *Amicus,* 2:37-41, June, 1977.

"Project Boosts Science Careers for Handicapped," *Chemical and Engineering News,* 56:20, April, 1978.

Rawls, Rebecca L. "Easing the Way for Handicapped in Science," *Chemical and Engineering News.* 56:25-27, January, 1978.

Redden, Martha R. "OOS to Address Research Problems in Science and Technology for Physically Handicapped Individuals, *Science,* 202:42, October 6, 1978.

Redden, Martha R., Cheryl A. Davis and Janet W. Brown. *Science for Handicapped Students in Higher Education.* Washington, D.C.: American Association for the Advancement of Science, 1978.

Redden, Martha R. and W. Schwandt (eds.). *Science, Technology, and the Handicapped.* Washington, D.C.: American Association for the Advancement of Science, 1976.

Redden, Martha R. and Virginia W. Stern. "Role Models for the Handicapped," *National Elementary Principal,* 58:43-45, October, 1978.

Ricker, Kenneth S. "Science and the Physically Handicapped," *Viewpoints in Teaching and Learning,* ed. Albert H. Fink, Vol. 55, No. 1 (in press).

Rowe, Mary Budd. "Help is Denied to those in Need," *Science and Children,* 12:23-25, March, 1975.

Rowe, Mary Budd. *Teaching Science as Continuous Inquiry.* Second Edition. New York: McGraw-Hill Book Company, 1978. (Chapter 14, "Doing Science with Handicapped Students and the Gifted.")

Safety in the Elementary Science Classroom. Washington, D.C.: National Science Teachers Association, 1978.

Safety in the Secondary Science Classroom. Washington, D.C.: National Science Teachers Association, 1978.

Schein, Jerome D. "The Deaf Scientists," *Journal of Rehabilitation of the Deaf,* 9:17-21, July, 1975.

Science-A Guide for Teaching the Handicapped. Washington, D.C.: U.S. Office of Education, Bureau of Education for the Handicapped, 1970.

"Science for the Handicapped," *Science and Children,* 16:4, October, 1978.

Walsh, Efthalia. "Lab Classroom: Breaking the Communication Barrier," *Science,* 196:1425, June 24, 1977.

Walsh, Efthalia. "The Handicapped and Science: Moving into the Mainstream," *Science,* 1424-1426, June 24, 1977.

B. Science and the Auditory Handicapped

Borron, Roberta. "Modifying Science Instruction to Meet the Needs of the Hearing Impaired," *Journal of Research in Science Teaching,* 15:257-262, 1978.

Boyd, Eunice and Kenneth D. George. "The Effect of Science Inquiry of the Abstract Categorization Behavior of Deaf Children," *Journal of Research in Science Teaching,* 10:91-99, 1973.

Burch, Daniel D. "A Report from the National Demonstration School for Curriculum Development," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman (Washington, D.C.: National Science Teachers Association, 1978), 90-95.

Burch, Daniel D. and Dennis W. Sunal. "Curricula for Young Hearing Impaired," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman (Washington, D.C.: National Science Teachers Association, 1978), 77-86.

Bybee, R. W. "A Review of Literature of Science for the Deaf," *Science Education,* 56:237-242, 1972.

Bybee, R. W. and P. A. Hendricks. "Teaching Science Concepts to Preschool Deaf Children to Aid Language Development," *Science Education,* 56:303-310, 1972.

Egelston, Judy C. and David Mercaldo. "Science Education for the Handicapped Implementation for the Hearing-Impaired," *Science Education,* 59:257-261, April/June, 1975.

Grant, William D., Joseh Rosenstein, and David L. Knight. "A Project to Determine the Feasibility of BSCS's ME NOW for Hearing-Impaired Students," *American Annals of the Deaf,* 120:63-69, February, 1975.

Hadary, Doris and others. "Breaking Sound Barriers for the Deaf Child," *Science and Children,* 14:33, November/December, 1976.

Hayden, Jean S. and Helen Woodward. "Rationale for a Science Program," *Volta Review,* 70:159-165, March, 1968.

"Helping the Deaf Hear," *SCIS Newsletter,* No. 27, Spring, 1975.

Lang, Harry G. "Teaching Physics to the Deaf," *Physics Teacher,* 11:527-531, December, 1973.

Leitman, Allan. *Science for Deaf Children.* Washington, D.C.: Alexander Graham Bell Association for the Deaf, Inc., 1968.

Lenth, J. William, "A Purpose for Science in a Curriculum for the Deaf," *American Annals of the Deaf,* 376-378, March, 1965.

Linn, Marcia and others. "Science Education for the Deaf: Comparison of Ideal Resource and Mainstream Settings," U. S. Educational Resources Information Center, ERIC Document, ED 154569, March, 1978.

Olsen, James. "Viewing Solar Crescents," *Science and Children,* 7:21, January/February, 1970.

Owsley, P. J. "Teaching Science to Deaf Children," *American Annals of the Deaf,* 107:399-42, May, 1962.

Roesch, Irvin H. "Analyses of Relationships Between Measures of Self-Actualization, Discovery Teaching Climate and Selected Characteristics of Secondary Science Students in Residential Schools for the Deaf," *Dissertation Abstracts International,* 36 (1976) 4408A.

Shultz, Ora Ann. "Planetarium Astronomy for the Hearing Impaired," *The Science Teacher,* 40:45-46, April, 1973.

Sutman, Frank X., Dorothy Manou, and Frederick Haselton. "Self Esteem and Vocabulary Through Photography," *Science and Children,* 14:17-18, January, 1977.

C. Science and the Orthopedic Handicapped

Beller, Joel. "Handicapped Students Learn a Helping Way of Life," *The Science Teacher,* 45:25-26, October, 1978.

Hall, J. Phil. "The Orthopedically Handicapped Child in the Regular Classroom," *Thrust for Education Leadership*, 4:17-19, May, 1975.

"Handicapped Students Get New Lab Bench," *The Science Teacher*, 45:12, October, 1978.

Nicholson, Charles L. "The Effect of a Series of Television Science Lessons on Learning by Cerebral Palsied Children," *Dissertation Abstracts* 30, (1969), 3818-A.

"Rick's A Part of the Team," *The Instructor Magazine*, 202-203, October, 1977.

Warren, Richard E. "A Research Program for the Physically Handicapped to Develop Independence via 'Build-It-Yourself-Kits' and Practical Instruction in Engineering Technology," R-1074 Progress Report, The Charles Stark Draper Laboratory, Inc., Cambridge, Massachusetts, April, 1977.

Wolinsky, Gloria. "Science Education and the Severely Handicapped Child," *Science Education*, 49:327-335, October, 1965.

D. Science and the Visually Handicapped

Akey, John M. "An Audiovisual Presentation for Non-Audiovisual Students," *The Science Teacher*, 41:52-53, December, 1974.

Baughman, James and Dean Zollman. "Physics Lab for the Blind," *The Physics Teacher*, 15:339-342, September, 1977.

Benham, Thomas A. "Aids for the Blind," *Electrical Engineering*, 66:178-182, February, 1947.

Benham, Thomas A. "Science for the Blind," *American Journal of Physics*, 23:177-178, March, 1955.

Benham, Thomas A. "Science for the Blind," *American Journal of Physics*, 24:45, January, 1956.

Boldt, Werner. "The Development of Scientific Thinking in Blind Children and Adolescents," *Education of the Visually Handicapped*, 1:5-78, March, 1969.

Brown, Dean R. "Science Instruction of the Visually Impaired: An Overview of Relevant Literature," (in press) *American Foundation for the Blind: Practice Report Series*, 1979.

Bryan, Arthur H. "Methods of Teaching Biology to Blind Students with the Seeing," *American Biology Teacher*, 12:75-81, April, 1950.

Bryan, Arthur H. "Science for the Blind," *Baltimore Bulletin of Education,* 29:14-15, September, 1951. Bryan, Arthur H. "Physics for the Blind," *Science Education,* 35:271-274, December, 1951.

Bryan, Arthur H. "General Science for the Blind," *Science Education,* 41:26-30, February, 1957.

Bryan, C. A. "Secondary School Sciences for the Blind," *International Journal for the Education of the Blind," 6:11-18, October, 1956.*

Bunner, William R. and Richard T. Bunner. "What about your Visually Defective Students?" *The American Biology Teacher,* 30:108-109, February, 1968.

Champion, Richard R. "Talking Calculator Used with Blind Students," *Education of Visually Handicapped,* 8:102-106, Winter, 1976.

Cooper, Katherine E. and Herbert D. Thier. "Do You Have to See it to Believe It?" *Learning,* 2:54-55, April, 1974.

Cranmer, T. V. "Liquid Level Indicator for the Blind: Electronic Device," *Popular Electronics,* 26:59-60, May, 1967.

Cravats, Monroe. "Biology for the Blind," *The Science Teacher,* 39:49-50, April, 1972.

Dawson, James R. "Biology for the Blind," *American Biology Teacher,* 20:42-44, February, 1958.

de Haaff, Susan Jean. "A Creative Science Project for Blind Children," *Journal of Visual Impairment and Blindness,* 71:458-459, December, 1977.

Eichenberger, Rudolph J. "Teaching Science to the Blind Student," *The Science Teacher,* 41:53-54, December, 1974.

Franks, Frank L. "Measurement in Science for Blind Students," *Teaching Exceptional Children,* 3:2-11, Fall, 1970.

Franks, Frank L. "Educational Materials Development in Primary Science: An Introductory Science Laboratory for Young Blind Students," *Education of Visually Handicapped,* 7:97-101, December, 1975.

Franks, Frank L. and L. H. Butterfield, Jr. "Educational Materials Development in Primary Science: Simple Machines," *Educational of Visually Handicapped,* 9:51-55, Summer, 1977.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Dial Thermometer Instructional Unit," *Education of Visually Handicapped,* 8:120-124, Winter, 1976.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: The Pull-Apart Cell," *Education of Visually Handicapped,* 8:16-30, Spring, 1976.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Insect Identification Kit," *Education of the Visually Handicapped,* 8:57-62, Summer, 1976.

Franks, Frank L. and Roger Huff. "Educational Materials Development in Primary Science: Linear Measurement Unit for Young Blind Students," *Education of the Visually Handicapped,* 9:23-28, Spring, 1977.

Franks, Frank L. and Marvin Murr. "Biological Models for Blind Students," *Journal of Visual Impairment and Blindness,* 72:121-124, April, 1978.

Fulker, Wilber H. and Mary Fulker. *Techniques with Tangibles.* Springfield, IL: Charles C. Thomas Publisher, 1968.

Gough, Elva R. "Blind Students Succeed in the Lab—Any Lab," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman Washington, D.C.: National Science Teachers Association, 96-101, 1978.

Gunderson, R. W. "Blind Improved Test Gear," *Radio Electronics,* 22:28-30, 1951.

Hadary, Doris E. "Picking up Good Vibrations from Science for the Handicapped," *The Science Teacher,* 42:12-13, December, 1975.

Hadary, Doris E. "Interaction and Creation Through Laboratory Science and Art for Special Children," *Science and Children,* 13:31-33, March, 1976.

Hadary, Doris E. "Science and Art for Visually Handicapped Children," *Journal of Visual Impairment and Blindness,,* 71:203-209, May, 1977.

Henderson, David R. "Laboratory Methods in Physics for the Blind," U.S. Educational Resources Information Center, ERIC Document ED 011 155, September, 1965.

Hiemenz, Paul C. and Elizabeth Pfeiffer. "A General Chemistry Experiment for the Blind," *Journal of Chemical Education,* 49:263-265, April, 1972.

Kaschner, Susan K. "Viewing the Earth with Closed Eyes," *Science Activities,* 15:12-13, Fall, 1978.

Bibliography

Kaufman, Abraham S. "Tutoring a Visually Handicapped Student in High School Chemistry," *The New Outlook for the Blind,* 65:313-317, December, 1971.

Lennon, Elizabeth M., John L. Feirer, and William K. Purdy. "Metrics for Visually Impaired Persons," *New Outlook for the Blind,* 70:1-4, January, 1976.

Lindecker, Ruth C. "Teaching Human Reproduction to the Visually Impaired in Science Classes," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman Washington, D.C.: National Science Teachers Association, 108-113, 1978.

Linn, Marcia C. "An Experiential Science Curriculum for the Visually Impaired," *Exceptional Children,* 39:37-43, September, 1972.

Linn, Marcia C. and Rita W. Peterson. "The Effect of Direct Experience with Objects of Middle Class, Culturally Diverse, and Visually Impaired Young Children," *Journal of Research in Science Teaching,* 10:83-90, 1973.

Linn, Marcia C. and Herbert D. Thier. "Adapting Science Materials for the Blind (ASMB): Expectation for Student Outcomes," *Science Education,* 59:237-246, April/June, 1975.

Long, Nancy T. "Science Curriculum Improvement Study (SCIS): Its Effect on Concept Development and Manipulative Skills in Visually Handicapped Children," *Dissertation Abstracts International* 34(1973) 1738A.

Mallinson, George C. "Programmed Learning for the Blind," Final Report, BR Project No. 55-00758. U.S. Educational Resources Information Center, ERIC Document ED 014 193, March, 1967.

Mallinson, George C. and Jacqueline V. Mallinson, "Symbolic Science Learning for the Blind," *School Science and Mathematics,* 67:432-449, May, 1967.

Recording Science Texts for the Blind. New York: American Foundation for the Blind, 1957.

SAVI Newletter. Science Activities for Visually Impaired, Berkeley, California. February, 1977; January, 1978; January, 1979.

Schatz, Dennis and Herbert D. Thier. "Increasing the Accessibility of Hands-On Science for Blind Students," *New Outlook for the Blind,* 70:61-63, February, 1976.

Schatz, Dennis and others. "Hands-On Science for the Blind," *Science and Children,* 13:21-22, March, 1976.

SCIS Newsletter. The Science Curriculum Improvement Study, Berkeley, California. No. 20, Spring, 1971; No. 22, Winter, 1972; No. 23, Fall, 1972; No. 24, Spring, 1973.

Struve, Nancy L. and others. "The Effect of an Experimental Science Curriculum for the Visually Impaired on Course Objectives and Manipulative Skills," *Education of the Visually Handicapped,* 7:9-14, March, 1975.

Struve, Nancy L. and others. "Materials Centered Science and Manipulative Skill," *Exceptional Children,* 40:516-517, April, 1974.

Tallman, D. E. "pH Titration Apparatus for the Blind Student," *Journal of Chemical Education,* 55:605-606, September, 1978.

Thier, Herbert D. "Laboratory Science for Visually Handicapped Elementary School Children," *The New Outlook for the Blind,* 65:190-194, June, 1971.

Thier, Herbert D. and Doris E. Hadary, "We Can Do It, Too," *Science and Children,* 11:7-9, December, 1973.

Thier, Herbert D. and others. *Adapting Science Materials for the Blind, Report of an Evaluation Planning Conference.* U.S., Educational Resources Information Center, ERIC Document ED 038 282, December, 1969.

Tiller, James E. and others. "An Experimental Rodent Chamber for Blind Students," *Behavioral Engineering,* 4:1-3, Fall, 1977.

Tobin, M. J. and others. "Programmed Learning for the Blind," *Education of the Visually Handicapped,* 2:11-23, March, 1970.

Tombaugh, Dorothy. "Laboratory Techniques for the Blind," *The American Biology Teacher,* 34:258-260, May, 1972.

Tombaugh, Dorothy. *Biology for the Blind.* Euclid, Ohio: Euclid Public Schools, 1973.

Tombaugh, Dorothy. "Mainstreaming Visually Handicapped in Biology," *A Working Conference on Science Education for Handicapped Students,* ed. H. Hofman Washington, D.C.: National Science Teachers Association, 167-171, 1978.

Weems, Bruce, "A Physical Science Course for the Visually Impaired," *The Physics Teacher,* 15:333-338, September, 1977.

Wexler, A. *Experimental Science for the Blind.* London: Pergamon Press, 1963.

Wright, Richard B. "Laboratory Exercises for Visually Handicapped Botany Students," *Journal of Visual Impairment and Blindness,* 72:67, February, 1978.

E. Extending the Science Program Beyond the School

Beechel, Jacque. "Interpretation for Handicapped Persons" *Journal of Environmental Education*, 6:34-44, Fall, 1975.

Brett, James J. "Pathways for the Blind," *Conservationist*, 25:13-16, June/July, 1971.

Garvey, Joseph. "Touch and See Nature Trail," *Science and Children*, 6:20-22, October, 1968.

Joels, Kerry M. *Museum and Handicapped Students: Guidelines for Educators.* Washington, D.C.: National Air and Space Museum, Smithsonian Institute, 1978.

McGrath, Ray. "Environmental Resource Center—Making the Outdoors Available to the Handicapped," *The Journal of Health, Physical Education and Recreation*, 44:46-48, January, 1973.

Piltz, Albert. "Gardening for the Blind Child," *Science and Children*, 6:25, October, 1968.

Schwartz, Jonathan R. "Survey of Nature Trails for the Visually Impaired," *Journal of Visual Impairment and Blindness*, 71:54-61, February, 1977.

Shugrue, Sylvia K., Walter M. Morris and Carolyn H. Kuhne. "Braille Trail Model," *Science and Children*, 6:23-24, October, 1968.

Spinelli, Tony and James Earley. "Successful Trails for the Blind," *The Journal of Environmental Education*, 3:43-44, Summer, 1972.

Stone, Edward H. "There's a Wheelchair in the Woods," *Park and Recreation*, 6:18-21, December, 1971.

Thomas, Barry. "Environmental Education for the Blind," *Instructor*, 86:106-107, May, 1977.

Note: Articles found in this Sourcebook *are not listed in the Bibliography.*

Selected Organizations and Agencies Concerned with the Physically Handicapped

Alexander Graham Bell
Association for the Deaf, Inc.
3417 Volta Place, N.W.
Washington, D.C. 20007

American Academy for Cerebral
Palsy
University Hospital School
Iowa City, IA 52240

American Association for
Health, Physical Education
and Recreation
1201 16th Street, N.W.
Washington, D.C. 20036

American Association for
Rehabilitation Therapy
P.O. Box 93
North Little Rock, AR 72116

American Association of
Workers for the Blind
1511 K Street,N.W.
Washington, D.C. 20005

American Corrective Therapy
Association, Inc.
811 Street Margaret's Road
Chillicothe, OH 45601

American Council of the Blind
818 18th Street, N.W.
Washington, D.C. 20006

American Diabetes Association
18 E. 48th Street
New York, NY 10017

American Epilepsy Society
Department of Neurology
University of Minnesota
Box 341, Mayo Building
Minneapolis, MN 55455

American Foundation for the
Blind
15 W. 16th Street
New York, NY 10011

The American Humane
Association
Agnes McGrath
Hearing Dog Program
5351 S. Roslyn Street
Englewood, CO 80110

American Library Association
Health and Rehabilitative
Library Services Division
50 East Huron Street
Chicago, IL 60611

American Occupational Therapy
Association
6000 Executive Blvd.
Rockville, MD 20852

American Physical Therapy Association
1156 11th Street, N.W.
Washington, D.C. 20005

American Printing House for the Blind
1839 Frankfort Avenue
Louisville, KY 40206

American Rehabilitation Counseling Association of the American Personnel and Guidance Association
1607 New Hampshire Avenue, N.W.
Washington, D.C. 20009

American Rheumatism Association
1212 Avenue of the Americas
New York, NY 10036

American Speech and Hearing Association
9030 Old Georgetown Road
Washington, D.C. 20014

Arthritis Foundation
1212 Avenue of the Americas
New York, NY 10036

Association for the Aid of Crippled Children
345 E. 46th Street
New York, NY 10017

Association for Education of the Visually Handicapped
919 Walnut Street
Philadelphia, PA 19107

Association of Rehabilitation Centers, Inc.
7979 Old Georgetown Road
Washington, D.C. 20014

Association for the Visually Handicapped
1839 Frankfort Avenue
Louisville, KY 40206

Better Hearing Institute
1430 K Street, N.W.
Suite 600
Washington, D.C. 20005

Bureau for Education of the Handicapped
Office of Education
400 Maryland Avenue, S.W.
Washington, D.C. 20202

Child Welfare League of America, Inc.
44 East 23rd Street
New York, NY 10010

Children's Defense Fund
1520 New Hampshire Avenue, N.W.
Washington, D.C. 20036

Clearinghouse on the Handicapped
Office for Handicapped Individuals
338 D Hubert Humphrey Bldg.
200 Independence Avenue, S.W.
Washington, D.C. 20201

Closer Look
National Information Center for the Handicapped
1201 16th Street, N.W.
Washington, D.C. 20036

Council for Exceptional Children
1920 Association Drive
Reston, VA 22091

Dialogue with the Blind
3100 South Oak Park Avenue
Berwyn, IL 60402

Epilepsy Foundation of America
1828 "L" Street, N.W.
Washington, D.C. 20036

ERIC Clearinghouse on
Exceptional Children
1411 South Jefferson Davis
Highway
Arlington, VA 22202

ERIC Clearinghouse on Science,
Mathematics, and
Enrivonmental Education
The Ohio State University
1800 Cannon Drive
400 Lincoln Tower
Columbus, OH 43210

Library of Congress
National Library Service for
Blind and Physically
Handicapped
1291 Taylor Street, N.W.
Washington, D.C. 20542

The Light House
111 E. 59th Street
New York, NY 10022

Muscular Dystrophy Association
of America
810 7th Avenue
New York, NY 10019

National Amputation
Foundation
12-45 150th Street
Whitestone, NY 11357

National Association of Hearing
and Speech Action
814 Thayer Avenue
Silver Spring, MD 20910

National Association of the
Physically Handicapped
6473 Grandville Avenue
Detroit, MI 48228

National Association for the
Visually Handicapped
3201 Balboa Street
San Francisco, CA 94121

National Center for Deaf-Blind
Youths and Adults
105 5th Avenue
New Hyde Park, NY 11040

National Center for Law and
the Handicapped, Inc.
1235 N. Eddy Street
South Bend, IN 46617

National Center on Educational
Media and Material for
Handicapped
371 Arps
1945 North High Street
Columbus, Ohio 43210

National Committtee for Multi-
Handicapped Children
239 14th Street
Niagra Falls, NY 14303

National Congress of
Organizations of the
Physically Handicapped
7611 Oakland Avenue
Minneapolis, MN 55423

National Cystic Fibrosis
Research Foundation
3379 Peachtree Road, N.E.
Atlanta, GA 30326

National Easter Seal Society for
Crippled Children and Adults
2023 West Ogden Avenue
Chicago, IL 60612

National Epilepsy League, Inc.
116 S. Michigan Avenue
Chicago, IL 60603

National Federation of the Blind
218 Randolph Hotel
Des Moines, IA 50309

National Foundation for
Infantile Paralysis
Box 2000
White Plains, NY 10602

National Foundation—March of
Dimes
800 2nd Avenue
New York, NY 10017

National Institute of Arthritis
and Metabolic Disease
Bethesda, MD 20014

National Institute of Health
United States Department of
Health, Education and
Welfare
Washington, D.C. 20014

National Multiple Sclerosis
Society
257 Park Avenue, South
New York, NY 10010

National Paraplegia Foundation
333 N. Michigan Avenue
Chicago, IL 60601

National Rehabilitation
Association
1522 "K" Street, N.W.
Washington, D.C. 20005

National Therapeutic Recreation
Society
1700 Pennsylvania Avenue,
N.W.
Washington, D.C. 20006

National Society for Prevention
of Blindness, Inc.
79 Madison Avenue
New York, NY 10016

President's Committee on
Employment of the
Handicapped
U.S. Department of Labor
Washington, D.C. 20210

Recordings for the Blind
215 East 58th Street
New York, NY 10022

Science for the Blind
Box 385
Wayne, PA 19087

United Cerebral Palsy
Association
66 E. 34th Street
New York, NY 10016

United Epilepsy Association
111 W. 57th Street
New York, NY 10019

Volta Speech Association for the
Deaf
1537 35th Street, N.W.
Washington, D.C. 20007

Professional Associations: Science Education

American Association for the Advancement of Science
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Association for Education of Teachers in Science
Dr. Ertle Thompson*
School of Education
University of Virginia
Charlottesville, VA 22903

Council of Elementary Science International
Doris Ensminger*
Administrative Assistant
Chesapeake Terrace Elementary School
2121 Lodge Farm Road
Sparrows Point, Maryland 21219

Council of State Science Supervisors
Lonie Love*
Science Supervisor
State Department of Education
State Office Building
Atlanta, Georgia 30334

Foundation for Science and the Handicapped
Dr. John Gavin, President
26827 Sturdy Oak Drive
Elkhart, IN 46514

National Association for Research in Science Teaching
Dr. Paul H. Joslin, Executive Secretary
Memorial Hall
Drake University
Des Moines, IA 50311

National Science Supervisors Association
Robert A. Dean*
Department of Education
San Diego County
6401 Linda Vista Road
San Diego, California 92111

National Science Teachers Association
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009

Science for the Handicapped Association
Dr. Ben Thompson, Secretary-Treasurer*
Department of Elementary Education
University of Wisconsin—Eau Claire
Eau Claire, WI 54701

---

*1979-80 Officers; contact with these Associations may be made through NSTA.

National Science Foundation Physically Handicapped in Science 1978

This list contains the National Science Foundation 1978 awards for projects designed to expand the participation in scientific careers of physically handicapped individuals with aptitude and interest in science. Similar awards were made 1977. List may be obtained from NSF.

State/Institution or Organization Address	*Project Director*	*Type of Activity*
California		
University of California Berkeley 94720	Lawrence F. Lowery	Study of Factors Affecting Disabled Individuals Seeking Careers in Science
Georgia		
University of Georgia Athens 30602	Kenneth S. Ricker	Modules in an Introductory College Laboratory Biology Course will be Analyzed by Groups of Visually Handicapped Students (A Resource Manual for College Instructors will be Prepared)
Indiana		
Ball State University Muncie 47306	Jay Church	A Four-Part Project to Identify College Bound Students, Conduct a Teacher Workshop, A College Orientation for High School Students and Teachers, and an Impact Evaluation

Maine

University of Maine Orono	Julian F. Haynes	A Three-Day Conference to Assess Education for the Physically Handicapped in Maine

Minnesota

St. Mary's Junior College Minneapolis 55406	Lawrence E. Demarest	Basic Science Course will be Modified Over A Two-Year Period to Meet the Needs of the Visually Impaired

New Jersey

New Jersey Institute of Technology Newark 07102	Harry Herman	A Workshop to Develop Special Aids and Training Models that will Permit Handicapped Students to Use Scientific Instruments

New York

Marist College Poughkeepsie 12601	Robert Rehwoldt	Student Science Training Project (20 Students)
Recording for the Blind, Inc. New York 10022	Emerson Foulke	Workshop Symposium on Tactual Perception (A Source Book will be Prepared)

Ohio

Kent State University Kent 44240	Nathan Spielberg	Apparatus and Equipment Used in Physics Laboratories will be Modified and Evaluated for Use by Paraplegics

Oregon

Oregon State University Corvallis 97331	Thomas P. Evans	Conference on Problems Faced by Physially Handicapped Students in Oregon

Pennsylvania

Schuylkill Valley Nature Center	Laura Lee Lienk	Student Teacher Training Project (40 Students and 40 Teachers)
University of Pittsburgh Pittsburgh 15213	Howard T. Blane	Student Development Project Involving Recruitment, Role Models, Counseling, and a Survey of Perception of Teachers and Counselors

Professional Journals

Selected Journals: Science Education

The American Biology Teacher
American Journal of Physics
BioScience
Chemistry
Education in Chemistry
GeoTimes
Journal of Biological Education
Journal of Chemical Education
Journal of College Science Teaching
Journal of Energy Education
Journal of Environmental Education
Journal of Geological Education
Journal of Research in Science Teaching
Physics Education
The Physics Teacher
Physics Today
School Science and Mathematics
Science
Science Activities
Science and Children
Science Education
The Science Teacher

Selected Journals: Physically Handicapped

American Annals of the Deaf
Audiology and Hearing Education
Education of Visually Handicapped
Exceptional Children
Exceptional Parent
Focus on Exceptional Children
Hearing and Speech Action
International Journal for the Education of the Blind
Journal of Rehabilitation of the Deaf
Journal of Speech and Hearing Disorders
Journal of Speech and Hearing Research
Journal of Visual Impairment and Blindness (replaces New Outlook for the Blind)
New Outlook for the Blind
Physical Therapy
Teaching Exceptional Children
Volta Review

5

Science and the Auditory Handicapped

5
Science and the Auditory Handicapped

Introduction

Probably the greatest challenge regular classroom teachers encounter when working with handicapped students is when they have an auditory handicapped student in their classroom. The lack of opportunities for many of these handicapped students to have continuous and effective communication with other people presents a serious problem. This lack of communication, along with the lack of other kinds of experiences, may result in lags in language and cognitive development. A properly designed science program can provide a variety of learning experiences that may enhance both language and cognitive growth, and help ward off developmental lags.

Following a review of the literature on teaching science to hearing impaired students, some characteristics relating to language development, cognitive growth, and personal-social traits of these students are discussed. Implications for teaching science to these students in the regular classroom are also presented. Modifications that schools for the deaf have made in their science programs are described. In an elementary school the Science Curriculum Improvement Study is used as the basis for the science program. The Model Secondary School for the Deaf is developing curricular and instructional materials to teach science to secondary school students. The chapter ends with the views of a deaf physicist on the lack of quality science education, particularly in the elementary school, for deaf students. His views are based on his visits to many schools in several different states.

Teaching Science to the Hearing Impaired: Literature Review

Dean R. Brown
Department of Education, Colorado State University, Ft. Collins, Colorado

This presentation will attempt to give an update on the current "state of the art" of science instruction of the hearing impaired by reporting the findings of an extensive search of the literature on this topic. Through the efforts of Ben Thompson (39) and his work with the Science for the Handicapped Association (SHA), an excellent reference entitled "Science for the Handicapped Bibliography" has provided valuable assistance in the preparation of this paper.

Although it is difficult to establish the exact number of handicapped students in the United States between the ages of 5-18 years of age, it has been estimated by several government agencies that based on 1978 population estimates, there are between six to nine million youths with some type(s) of handicapping conditions, Gearheart, Weishahn (15). Approximately 0.6-0.8% of the school population or 330,000-440,000 students would be identified as having a type of hearing loss, enough to be classified as hearing impaired. For the purposes of this paper, the term hearing impaired will be used to include the entire range of auditory impairments, inclusive of the deaf child as well as the child with a very mild loss, Moores (23). Deaf and acoustically impaired will also be used if these terms are so used by the referred authors. Davis (10) and Moores agree that there is much confusion among professionals with the inability to reach consensus on terminology, but both agree on the term hearing impaired as a functional definition.

■

. . . there are no national science curricula designed specifically to teach the hearing impaired, so it is the role of the science teacher or special educator to adapt existing methods and materials to accommodate the language impairment that deafness usually involves.

At the present time, there are no national science curricula designed specifically to teach the hearing impaired, so it is the role of the science teacher or special educator to adapt existing methods and materials to accommodate the language impairment that deafness usually involves. As this paper will indicate, some investigators have successfully adapted programs such as Science Curriculum Improvement Study (SCIS), Science-A Process Approach (S-APA), Elementary Science Study (ESS), and Biological Sciences Curriculum Study (BSCS) ME NOW with hearing impaired students, but the majority of teachers are still searching for materials, methods and curricular aids to utilize in making science a successful experience for handicapped youth.

The language performance of the average hearing impaired child compared to that of his normally hearing peers demonstrates an ever-increasing gap in vocabulary growth, concept formation, and ability to comprehend and produce complex sentences, Davis (10). Because language and speech are seen as the major need for hearing impaired youth, content areas such as science and mathematics receive low instructional priority. Moores (23) suggests that often class time designated for academic subjects is devoted entirely to speech and language remediation. Since most teachers of the hearing impaired have not been trained in subject matter, just as most science teachers have not been trained in special education, the tendency to sacrifice content is intensified. Furth's (13) criticism of deaf education deals mainly with this intellectual neglect, and is the basis of this appeal for more cognitively based learning experiences. Problems with communication are further complicated by the continued controversy over suitability of modalities or channels of communication, auditory/aural versus visual.

What does the preceding say to us as science educators regarding the education of our hearing impaired youth? How do we fit the uniqueness of the processes of science into a most worthwhile program, be it in the residential, day school, resource room, or in a mainstreamed science classroom. Science educators have an inherent advantage over teachers of other content areas due to a positive motivation and a high occurrence of hands-on activities in most materials and activities used, Egelston, Mercaldo (11). Hearing impaired children are scientists by disposition according to Owsley (26). They ask questions and use their remaining sensory channels as well as reasoning powers to explore their physical environment. Science can be of great assistance to the teacher of the hearing impaired in the development of cognitive skills and language because of the high interest level and great variety of ideas to be explored. Jerome Bruner (6) in describing the translation of experience into language states: "But it is obviously not language per se that makes the difference; rather, it seems to be the use of language as an instrument of thinking that matters, its internalization. The very young child uses language almost as an extension of pointing, and recent work shows that the likelihood of a word's use in the early linguistic career of the child is vastly increased if the object is either in hand or in direct sight."

Hearing impaired children are scientists by disposition according to Owsley (26). They ask questions and use their remaining sensory channels as well as reasoning powers to explore their physical environment.

Athey (2) implies that language cannot always be relied upon to convey concepts to a child. Piaget (28) states that children may verbalize without understanding, just as they may understand without being able to verbalize. He has demonstrated that the ability of children to deal with broad concepts depends on their direct sensory experience. Mary Budd Rowe (35) suggests that in order for language to develop rapidly in the context of science activities, it is necessary to have all data available to every child. Hearing impaired youth can profit from a somewhat prolonged exposure to directed experiments designed to focus attention on patterns of interaction in physical and biological systems, and can develop more elaborate forms of thinking with early success in reasoning about what they observe and how systems respond to manipulation. They can move from the concrete level, by direct manipulation, to more complex problems which may require symbolic representation. When transformed to an abstract form, these problems may be solved quickly. Rowe gives an example of two circles of different areas from which the child is to determine the number of small circles which would be equivalent to the area of the larger circle. The concept of area may be solved by ignoring the shape of the object and reasoning only in regard to area equivalence. As the teacher watches the process by which children proceed, she can observe how they are thinking by "what they do" as much as by "what they try to say." Thus language grows in the context of verifiable experience.

The goal of science education as the goal of the education of the hearing impaired, is the development of formal thought, Babbidge (3), National Science Teachers Association (NSTA) (24), Simmons (37). Boyd and George (5) indicate the most effective and efficient means of achieving this goal is through inquiry. They define inquiry as "the mode of learning whereby one discovers relationships through his own activity. This activity may involve physical interaction with the things of the environment or mental manipulation of conceptual schemes, depending upon the intellectual maturity of the inquirer." In their study, the authors investigated a pedagogical approach to the education of the deaf that stresses sensory experience rather than language attainment. Studies conducted over the past two decades have shown evidence that the abstract mental abilities of the deaf child is significantly inferior to those of his hearing peers, Larr (20), NSTA, (24), Oleron (25). Boyd contended that a hearing impaired child's lack of normal abstract skills is directly related to restricted experiential input, and only indirectly is the lag related to language deficiency. Twenty-six students between the ages of ten and thirteen were pretested using the Goldstein-Sheerer Object Sorting Test. This instrument is designed to measure the conceptual categorization behavior of the individual. The experimental group participated in 30 inquiry lessons, each half-hour lesson was designed to increase classificatory skills through physical manipulation of objects. The control group continued the regular course of study in science at the Ryan Institution for the Deaf. Statistical analysis of post-test results indicated a significant difference between the groups. It was concluded that the conceptual categorization skills of deaf children can be substantially increased through the use of specific experiences in classification and physical manipulation of objects. Furth's (12) postulate that the deficient classificatory behavior of the deaf is the result of experiential restriction in early life is clearly supported by the results of this study.

■

. . . a hearing impaired child's lack of normal abstract skills is directly related to restricted experiential input, and only indirectly is the lag related to language deficiency.

Bybee and Hendricks (7) conducted a study emphasizing language growth through science instruction with seven preschool deaf children using SCIS and ESS materials. After ten weeks of concept (word) building, the authors, from evaluation/observation, concluded that young deaf children can learn science concepts and increase their vocabulary; direct experience with objects is essential to learning; immediate nonverbal feedback from the teacher is essential, and the utilization of objects found in the child's immediate environment enhances the learning of concepts for the deaf child. Modern communication specialists employ similar real-life experiences to enable them to enhance communication skills of youth with speech and language problems. Traditional language remediation, based on rote memory, has failed, Babbidge (3).

The importance of language in science is also stressed by McIntyre (22). Concepts need to be discussed and will have relevance by hearing impaired children taking part in sensory experiences such as smelling, tasting, touching and seeing investigations. Collea (9) at the Oralingua Day School found SCIS to be very effective with congenitally deaf or severely hard of hearing children. The concepts of system and interaction can be understood when applied in a variety of ways such as by using pulleys, springs, magnets, and rubber bands. In this program, SCIS provided the repetitious techniques for cognitive development, listening skills and language expansion and was readily integrated into the total school curriculum.

Owsley (27) presents a strong argument for the necessity of critical thinking, reasoning and problem solving with a de-emphasis on facts. Rowe (34) states that science attitudes are influenced and curiosity levels raised by student involvement in demonstrations and lab work, rather than learning exclusively from a textbook. Furth (12) hypothesizes that demonstrations help close the gap between deaf children and their hearing peers and concludes that linguistic experience has no substantial impact on a child's mental image of spatial transformation. Consistency of this remark is verified by Piaget's (29) statement that "spatial understanding, like other systems of operations is attained through active personal exposure to handling of spatial situations, regardless of linguistic ability." The importance of laboratory based math and science for the handicapped is also emphasized by Post (30) who feels that hands-on experiences are essential to understand metric concepts.

Several researchers have described and employed the BSCS "ME" programs with handicapped children. Ken Ricker (33) has given an excellent description of the ME NOW program designed for Educably Mentally Handicapped (EMH) students ages 10-13. The four life science units, Digestion and Circulation; Respiration and Body Waste; Movement, Support and Sensory Processes; and Growth and Development should be readily adaptable to other programs including regular science classes at the elementary and intermediate levels. Egelston (11) discusses the adaptability of ME NOW to hearing impaired students because the program is commercially available; permits control of verbally presented information by the teacher; and is a valid science course. Grant (16) initiated ME NOW with six hearing impaired students with low verbal skills at the Model School for the Deaf. The students, with a mean chronological age of 18-1, and a hearing loss ranging from 61dB to 100dB in the better ear, pretested below fifth grade levels on the Science Subtests of the Stanford Achievement Test. With strict adherence to program manuals, the materials and concepts were covered in their entirety in four months. From the study's findings, it was concluded the ME NOW program brought about increased cognitive gains when compared to the target EMH population for whom the program was originally intended. Grant reports the most important finding to be the large amount of retained information in the High cognitive category.

Other interesting and noteworthy findings have been revealed during this literature search. Doris Hadary and associates (17) have developed, among other outstanding curricula for handicapped youth, a comprehensive combined sequential laboratory and art curriculum for deaf elementary school children. Experiments emphasizing discovery, selected from SCIS, S-APA and ESS, were utilized with twenty profoundly deaf children ages 6-11, who used different communication modes. These youth were bused three times per week to regular classrooms for two-hour sessions of laboratory science and related art lessons. Results show communication barriers were broken through the experiental approach to science by using the relationship of expression in art form and the adaptation of special language for each lesson. The project is also concerned with training teachers to use the program in mainstreamed situations.

■

. . . "doing science" with these youth can be accomplished effectively with a variety of methods and stimulating environments.

Other investigators have reported studies done with the hearing impaired lending credence to the notion that "doing science" with these youth can be accomplished effectively with a variety of methods and stimulating environments. How do you communicate astronomy in a planetarium to students who have lost the senses of sight or hearing? John Akey (1), with a group of intermediate level students from the Colorado School for the Deaf and Blind, used media with the deaf including an overhead projector, chalkboard, sign language and a 35mm slide projector with special high contrast film-slides to point out names of constellations, stars and other interesting features of the sky. He found the most effective method for the deaf child to be the projection of 35mm slides with captions as each constellation outline was projected. Schultz (36), also after experimenting with various methods, reported that a photo offset negative on an overhead projector successfully projected typed instructions clearly on the planetarium dome.

A course in photography was piloted by Sutman (38) for twelve middle school students from the Pennsylvania School for the Deaf. Course Objectives: to motivate deaf children to learn new motor skills, develop a greater sense of self esteem, learn new vocabulary and possibly develop an interest in a future vocation, seemed to be met. Gaskins (14) found that through horseback riding, handicapped children can apply to their own self awareness, experiences learned from riding skills and caring for animals. Sensitivity to cares and needs of both living and inanimate objects can be applied to everyday learning.

Several excellent sources of relevant activities for teachers of the handicapped have also been revealed during this study. Cliff Baker (4) through a grant from Health, Education, and Welfare (HEW) has produced an excellent set of in-service and pre-service learning activities and resources for elementary teachers to use with special needs students in the mainstreamed classroom. Secondary units are now being developed for various subject matter areas including science.

Allan Leitman (21) has written a book, *Science for Deaf Children,* with some good examples of activities and experiences for students pre-school through advanced levels. *The Logic of Action* by Frances Hawkins (18) is a notebook of experiences gained while teaching thirteen science lessons to preschool deaf children and contains plans and descriptions of children's interaction with materials, both living and non-living. The Jefferson County School District, Lakewood, Colorado, has a good *Deaf Education Guide* which includes curriculum content, objectives and resources preschool through intermediate levels, including a section on Science and Bionomics (19). A recent book published by Coble (8), *Mainstreaming Science and Mathematics* contains many ideas and activities for exceptional youth and is intended for all students in any elementary class to be taught by the regular classroom teacher. In regard to literature on mainstreaming the deaf and other handicapped youth, Maynard Reynolds (31) has been an early advocate and outstanding leader in this field. He has researched and written a number of excellent papers and texts, the most recent entitled *Teaching Exceptional Children in All America's Schools* co-authored with Jack Birch (32), in cooperation with the Council for Exceptional Children.

. . . hearing impaired student can increase: language performance, observing and listening skills, vocabulary, the learning of science concepts and development of cognitive skills through direct, experiential sensory experiences in science.

In summary, the literature investigated indicates that the hearing impaired student can increase: language performance, observing and listening skills, vocabulary, the learning of science concepts and development of cognitive skills through direct, experiential sensory experiences in science. In order for this learning to occur, the researchers express repeatedly the necessity of "doing science" by hands-on, inquiry, real-life experiences through direct physical manipulation of objects that focus attention on patterns of interaction in physical and biological systems.

Although no national systematic effort to develop curricular materials and delivery systems has emerged, it is evident that many innovative educators in science have adapted and/or modified specific national curricular project materials for the instruction of their hearing impaired students. Others have developed their own special strategies and materials of instruction. There seems then, to be a definite need for cooperative efforts by science, general and special educators to work together setting goals, planning strategies, and developing curriculum and materials that would enrich and enhance the science education of the hearing impaired youth of our country.

References

1. Akey, John. "An Audiovisual Presentation for Non-Audiovisual Students." *The Science Teacher,* December, 1974.

2. Athey, J. and O. Duane Rubadeau, Editors. *Educational Implications of Piaget's Theory.* Ginn Blaisdell, xvi, 1970.

3. Babbidge, H. "Education of the Deaf in the United States." *Report of the Advisory Committee on Education of the Deaf.* Washington, D.C.: U.S. Government Printing Office, 1965.

4. Baker, Clifford D. *The Preparation of Regular Classroom Teachers to Work with Students with Special Learning Problems: A Preservice Training Project.* Greeley, Colorado: Department of Special Education and Rehabilitation, University of Northern Colorado, 1976.

5. Boyd, Eunice and Kenneth D. George. "The Effect of Science Inquiry on the Abstract Categorization Behavior of Deaf Children." *Journal of Research in Science Teaching,* 10, No. 1, 91-99, 1973.

6. Bruner, Jerome S. *Toward a Theory of Instruction.* Cambridge, Mass.· The Belknap Press, 14, 1966.

7. Bybee, R. W. and P. W. Hendricks. "Teaching Science Concepts to Pre-School Deaf Children to Aid Language Development." *Science* Education, 56, No. 3, 303-310, 1972.

8. Coble, C. R., Paul B. Hounshell, and Ann H. Adams. *Mainstreaming Science and Mathematics:* Special Ideas and Activities for the Whole Class. Santa Monica, Calif. Goodyear Publishing Co., Inc. 1977.

9. Collea, Francis P. "Science in Sounds." *Science and Children,* 13:34, March 1976.

10. Davis, Julia D. Editor. *Our Forgotten Children: Hard of Hearing Pupils in the Schools.* Minneapolis, Minn. Audio Visual Library Services. 1977.

11. Egelston, Judy C. and Mercaldo, David. "Science Education for the Handicapped: Implementation for the Hearing Impaired." *Science Education,* Volume 59, Issue No. 2, 257-261, April-June 1975.

12. Furth, Hans G. *Deafness and Learning: Psycho-Social Approach.* Belmont, Calif. Wadsworth Publishing Company, Inc. 1973.

13. Furth, Hans G. *Thinking Without Language-Psychological Implications of Deafness.* New York, N.Y. Free Press, 1966.

14. Gaskins, Marinda H. "Horseback Riding and the Handicapped." *Science and Children,* 23, March 1976.

15. Gearheart, Bill R. and Mel W. Weishahan. *The Handicapped Child in the Regular Classroom.* St. Louis, Mo. The C. V. Mosby Co. 1976.

16. Grant, William D. "A Project to Determine the Feasibility of BSCS's *Me Now* for Hearing-Impaired Students." American Annals of the Deaf, 120, No. 1, 63-69, February 1975.

17. Hadary, Doris and Others. "Breaking Sound Barriers for the Deaf Child." *Science and Children.* 14:33, November/December 1976.

136

18. Hawkins, Frances P. *The Logic of Action, From a Teacher's Notebook.* Boulder, Colorado. Mountain View Center for Environmental Education. 1969.

19. Jefferson County. *Deaf Education Guide.* Curriculum for Deaf Education. Science/Bionomics XV. Lakewood, Colorado. Jefferson County School District R-I. 1974.

20. Larr, A. "Perceptual and Conceptual Abilities of Residential Deaf Children." *Exceptional Children,* 23, 63-66, 1956.

21. Leitman, Allan. *Science for Deaf Children.* Washington, D.C. Alexander Graham Bell Association for the Deaf, Inc. 1968.

22. McIntyre, Margaret. "Science is for All Children." Science and Children, 13:50-51, March 1976.

23. Moores, Donald F. *Educating the Deaf-Psychology, Principles, and Practices.* Boston, Mass. Houghton Mifflin Co. 1978.

24. National Science Teachers Association, *Theory Into Action,* National Science Teachers Association. Washington, D.C. 1964.

25. Oleron, P. "A Study of the Intelligence of the Deaf." *American Annals of the Deaf.* 98, 304-310. 1950.

26. Owsley, Peter J. "Development of the Cognitive Abilities and Language of Deaf Children Through Science." *Volta Review.* Curriculum: Cognition and Content. Washington, D.C., A.G. Bell Assoc. 1968.

27. Owsley, P. J. "Teaching Science to Deaf Children." *American Annals of the Deaf,* 107: 339-42 May 62.

28. Piaget, Jean. "Development and Learning." *Journal of Research in Science Teaching.* 2(3): 176-185. 1964.

29. Piaget, Jean. *Science of Education and the Psychology of the Child.* New York, N.Y. Orion Press. 1970.

30. Post, Thomas R., Alan H. Humphreys and Mickey Pearson. "Laboratory-Based Mathematics and Science for the Handicapped Child." *Science and Children,* 13:41-43, March 1976.

31. Reynolds, Maynard C. Editor. *Mainstreaming: Origins and Implications.* Council for Exceptional Children. Reston, VA. 1976.

32. Reynolds, Maynard C., and Jack W. Birch. *Teaching Exceptional Children in All America's Schools.* Council for Exceptional Children. Reston, Va. 1977.

33. Ricker, Kenneth S. "ME NOW" *Science and Children,* 13:37-38. March 1976.

34. Rowe, Mary Budd. "Help is Denied to Those in Need." *Science and Children,* 12:23-25, March 1975.

35. Rowe, Mary Budd. *Teaching Science as Continuous Inquiry.* New York: McGraw-Hill Book Company, 1973. (Chapter 13: "Doing Science with Handicapped Students").

36. Shultz, Ora Ann. "Planetarium Astronomy for the Hearing Impaired." *Science Teacher,* 40:45-6 April, 1973.

37. Simmons, A. "Content Subjects Through Language." *Volta Review.* 70, 481-486. 1968.

38. Sutman, Frank X., Dorothy Manou, and Frederick Huselton. "Self-Esteem and Vocabulary Through Photography." *Science and Children,* 14:17-18, January 1977.

39. Science for the Handicapped Association. Ben Thompson, Editor. *Science for the Handicapped Bibliography,* updated September 1977. Eau Claire, Wis. 1977.

Hearing-Impaired Physics Students and Implications for Teachers

Harry G. Lang
National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, New York

Although the first school for the deaf in the U.S. was founded in the early nineteenth century, the history of teaching science to deaf children and youth is largely a *terra incognita.* Little legitimate research has been reported in the literature on pedagogical and programmatic efforts in the area of science teaching for deaf children. Occasional articles appear in the literature with no synthesis or common aim. These random efforts to seek success in science curricula are deserving of our commendation. But where is the objective educational research we need so badly at this point of transition in our history? We now have government edicts to "mainstream" deaf children into regular schools. These mandates, such as Public Law 94-142, the "Education of All Handicapped Children Act," are as important to the sociological dimension of education as the laws on equality of race and sex over the past few decades.

Legally we have made great gains with Public Law 94-142. But realistically, how do we expect to succeed in upgrading the education of deaf children when we have such a dearth of objective research on how deaf children learn?

A review of the literature reveals no major theories of instruction for deaf children. In the area of science education, in particular, various strategies and pedagogical techniques have been reported upon in the past, but seldom do they manifest more than subjective summaries of individual stabs in the dark.

Importantly, these reports do point out some significant characteristics of the more successful curricula. What is more fortunate, however, is the fact that the most favorable strategies are the major components of contemporary science curriculum projects for non-handicapped children and youth—individualization of learning, discovery-learning, self-pacing, "hands-on" experiences, etc.

. . . discovery-learning, self-pacing, "hands-on" experiences, etc . . . . makes mainstreaming all the more meaningful as a workable solution to the challenging problem of teaching science to the deaf.

This makes mainstreaming all the more meaningful as a workable solution to the challenging problem of teaching science to the deaf.

As a point of focus, this paper will deal with some educationally significant traits of deaf youth pertaining to the area of Physics. Practically all of the characteristics described in this paper are generally applicable to other disciplines of science education. It has been the writer's experience, however, to teach Physics to deaf youth for the past seven years.

Language

The lag in language development presents three common problem areas in the Physics classroom. Walter (1977) describes these factors as syntactic, lexicon and experiential. Walter believes the rules of syntax are probably related to the ability of hearing-impaired students to understand what is being expressed in the sentence. In Physics, for example, we may say that "the force caused the acceleration." The deaf student may confuse the subject and object in a sentence like this, reversing them by saying "the acceleration caused the force." The deaf student had little previous experience in constructing verbal relations of physical causality. It is no wonder that complicated sentence structures are even more difficult for the language-handicapped deaf student. Consider, for example, the problems presented by the sentence "the acceleration of the body was caused by an external, unbalanced force."

The second general factor which Walter describes and which is characteristic of deaf Physics students as well, is that of lexicon (vocabulary). Many of the subtleties of the English language are largely unacquired by the time the deaf student reaches high school. One particular error is the substitution of words which are inappropriate within a given context. The deaf student may say "the combination of all colors is caucasian," having been taught that "caucasian" loosely means "white," a chemical solution was "concealed," meaning that it was "covered" or that the results of the data "consented" instead of "agreed" with each other.

The lexicon factor also includes the use of idioms such as "to come across" or "to get with it" and abstract terms such as a "state" of balanced forces, the "tendency" to remain in motion or the "will" to live. These are difficult to explain properly.

In an article on teaching Physics to culturally disadvantaged students, Franklin (1973) describes how a sailboat was an inappropriate choice for illustrating vector forces since many of the students in his class had never been in, or even seen, a sailboat before. There are interesting parallels to Franklin's example in teaching Physics to the deaf. The experiential factor is as important as those of syntax and lexicon deficits. Deaf children and youth are experientially deprived, missing out on many of the primary and vicarious experiences that make up the normal daily activities of most children.

Deaf children and youth are experientially deprived, missing out on many of the primary and vicarious experiences that make up the normal daily activities of most children.

Just as Franklin found the sailboat ineffective with culturally-disadvantaged students, Physics teachers must consider both the general experiential deprivation as well as the acoustical deprivation of the hearing-impaired student. When teaching the Doppler Effect and frequency change, for example, one would be much more successful using a ripple tank than to discuss this at length verbally. Hands-on experiences and visual (or even tactual) reinforcers are very helpful. The oscilloscope can be used with most acoustics demonstrations including the commonly-used Resonance-Tube experiments in high school Physics. But these visually augmented demonstrations cannot replace in importance a teacher's sensitivity to, and awareness of, the effects of this lack of experience on performance in English reading and writing skills.

Many of the lexicon and syntax problems can be worked on with the assistance of a resource person who will help the hearing-impaired students with note taking and/or tutoring.

When developing instructional materials and when grading, a Physics teacher with a deaf student must decide whether context or syntax is more important. The deaf student has difficulty with organization and expression when writing lab reports, although the context is often accurate and complete.

Teachers should also work closely with the resource personnel in deciding whether test questions are written to evaluate the deaf student's ability to show mastery of that particular skill being tested or the student's capability to read a verbally overloaded test item. The writer encourages more use of criterion-referencing to assess both deaf and hearing students and their individual or absolute achievement scores rather than their relative achievement across a norm-referenced domain.

■

. . . more use of criterion-referencing to assess both deaf and hearing students and their individual or absolute achievement scores rather than their relative achievement across a norm-referenced domain.

Cognitive Growth

A language lag by no means implies a cognitive deficit. Research has provided sufficient evidence that the linguistic deficit hypothesis is losing its credibility. Piaget and Inhelder (1969) and Furth (1966) have for years expounded their beliefs that thought precedes language. Although language facilitates the development of thought, it is not a prerequisite for cognitive growth. Moreover, cognitive growth in deaf children between six and twelve years of age is considerably greater than growth in language.

Deaf children do lag in cognitive development, frequently from two to four years. The lag may be attributed to a number of factors. These factors include, in varying degrees of complexity, experiential deprivation, philosophies of communication, teaching methods, test bias, and others. But none are as significant as social class which is, itself, a composite of significant variables.

Deafness as a loss of hearing is a "disability." The secondary effects on language development, socialization and cognitive growth are "handicapping" conditions which result from society's treatment of the deaf child. The extent to which these conditions become handicaps depends on personal and societal expectations.

Hanner *et al* (1971) described some general "information processing" traits of deaf students, most of which, however, are shared with their normal-hearing peers in the science classroom. Deaf students tend to learn by rote rather than from understanding, have difficulty reasoning logically and tend to oversimplify problems, responding hastily without careful analysis. They often have difficulty in applying knowledge learned in one context to the solution of other problems, and in identifying exceptions to a principle. But if we examine the literature on teaching Physics over the past few years, we see these traits as common concerns of most Physics teachers. In fact, there has been a recent trend in Piagetian-based Physics curricula (Renner and Lawson, 1973; Fuller *et al.*, 1977, etc.) where the primary goal is to develop formal thought in the students.

Tomlinson-Keasey and Kelly (1974) describe how auditory feedback and the experiential deprivation of deaf children provide them with far fewer opportunities to develop abstract thinking processes. One of the characteristics of formal operational thought is the ability to hypothesize and consider all of the possibilities that exist. A hearing child, upon hearing a knock at the door while playing, for example, may hypothesize "maybe it's the mailman," or "maybe Jimmy has come over to play." Possible alternatives are anticipated. "It must not be daddy . . . he never knocks" or "maybe it is grandma."

The deaf child has far fewer experiences such as this one. Also missing is the opportunity to hear mom and dad discussing the different possibilities or alternatives for some future project.

What this means is that the deaf child has all the potential to develop abstract thought as a hearing child, but there will be a chronological delay. The Physics teacher should be sensitive to this lag. The writer recommends providing both a rich environment and increased experience with abstractions. Furth and Youniss (1969) have shown that deaf adolescents were capable of devising a strategy for solving formal operational tasks after several weeks of practice. Deaf students need strong but reasonable demands to stimulate logical, creative and effective thinking in the Physics classroom and laboratory.

■

Deaf students need strong but reasonable demands to stimulate logical, creative and effective thinking in the Physics classroom and laboratory.

Personal-Social Traits

As with the cognitive and linguistic traits, psycho-social dimensions of deafness are largely attributable to experiential deprivation and social impoverization, a number of these traits being directly observable in the Physics classroom.

The deaf student is usually deficient in understanding himself/herself and the implications of deafness is a disability. The cognitive link (lack of experience in generalizing, hypothesizing, etc.) may in part explain why the deaf student is deficient in seeing the relation to others and to society in general. As with most hearing students, deaf youth frequently have poorly defined career objectives. Surprisingly, many deaf students have never learned of deaf notables such as England's Cornforth (1976 Nobel prize-winner chemist) and America's Thomas Edison, both potential role-models for inspiring careers in science.

■

The deaf student is often reluctant to admit s/he does not understand.

Another trait which Hanner *et al* describes is very important to the Physics teacher in a mainstream environment. The deaf student is often reluctant to admit s/he does not understand. To cope with this problem, the writer suggests that the teacher takes care not to exclude the deaf student from any responsibilities. Use the interpreter or resource person efficiently, involving the deaf student as much as possible in the classroom and laboratory activities. Keep a close check on the deaf student's progress until you feel comfortable that a meaningful and worthwhile relationship has been established with hearing peers.

Brief Review of the Literature

With the exception of a previous publication by this writer a few years ago, (Lang, 1973), there is practically a complete absence of literature on deaf students in Physics. Various educators of the deaf, however, have described some curricular strategies that have worked with deaf children and youth in general science areas. Anselmini (1967), for example, describes the importance of a careful sequence of topics in which new material is related to that previously learned. Bybee (1972) includes in his review two Soviet studies with deaf children. Both Titova (1964) and Tigranova (1965) recommend relating new skills and knowledge to that previously acquired.

The writer believes deaf students, in particular, learn much more effectively when the topics are sequenced carefully, particularly in an abstract subject like Physics. If the topics are structured in a way that knowledge can easily be related to concepts already acquired, the student will be able to advance from the simple to the more complex, the concrete to the more abstract, the practical to the more theoretical aspects of general physics, and will also learn less by rote and more for understanding if the teacher reinforces the acquisition of new knowledge and skills through applications and demonstrations which make use of the visual and tactual modalities. Deaf students who are learning Newton's Second Law, for example, will frequently master the concept more readily if the teacher not only presents the relationships among force, mass and acceleration but relates this to velocity and time and other measurements learned previously. This is where "hands-on" experiences become extremely valuable in teaching the deaf. There is nothing like the experimental determination of the value of gravity using an air track to show these interrelationships. The Atwood machine and many other applications of the Second Law which *visually* reinforce the principle will surely help the entire class of both hearing and deaf students acquire a better understanding of the subject.

■

. . . applications of the Second Law which visually reinforce the principle will surely help the entire class of both hearing and deaf students acquire a better understanding of the subject.

Anselmini also emphasized the importance of "hands-on" experiences and the use of mediated materials, as have Owsley (1968) and Lang (1973).

The focus of Lang's paper was on the success of the individualized instruction method with deaf students. Leitman (1968) and Cohen (1967) also call for increased attention to the individual needs of deaf youth in science classrooms. Fitzgerald (1968) believes that flexibility in teaching facilities, class schedules and the use of instructional materials is another important factor in a successful curriculum for deaf learners.

Most of these dimensions of teaching Physics to the deaf are well-known components of contemporary science curricula. They are not new to Physics teachers in mainstream programs. In fact, they are all ingredients of the Keller Plan, PSI Physics and the PSSC and Harvard Projects, which have become increasingly popular in secondary schools over the past decade. There have been exciting attempts to individualize both the PSSC (Friedman, 1976; Gabel, 1973) and Harvard Physics Project (Collins and Madden, 1974) and even to combine both in a multi-track program (Smith and Euller, 1973). This trend toward increasing the flexibility in physics teaching will be an asset in a successful mainstreaming program.

Summary

The linguistic, cognitive and psycho-social traits of deaf students are handicapping conditions imposed upon them by society. A few of them which stand out in the Physics classroom, in particular, have been discussed in this paper. It cannot be overemphasized that deaf students are *individuals* with a wide range of communication skills, academic preparedness and personal and social maturity as well as motivation and attitude. Not every deaf student is capable of being mainstreamed. Those who are should receive the most accommodative ("least restrictive") environment possible, and this can only be accomplished through the co-operative efforts of teachers, administrators and professionals in the field of education of the deaf.

It cannot be overemphasized that deaf students are individuals with a wide range of communication skills, academic preparedness and personal and social maturity as well as motivation and attitude.

A Physics teacher who encounters a deaf student in class should immediately seek the advice and assistance of the resource personnel who will be assigned to the school. Each student should have his/her own program of study planned. The Individualized Education Program (IEP) is an effective means of enhancing a deaf teenagers' mainstreaming experience.

Mainstreaming has the potential for opening up an exciting new avenue for improving science instruction for the deaf. The success of Public Law 94-142, however, hinges greatly upon the humanistic dimension of society. This paper is a call for Physics teachers to integrate a little more of the affective with the cognitive.

Bibliography

Anselmini, A. A Science Program in a School for the Deaf. *Proceedings of the International Conference on Oral Education of the Deaf.* Washington, D.C.,: The Volta Bureau, 1967.

Bybee, R. A Review of Literature on Science for the Deaf. *Science Education,* 1972, 56, 237-242.

Cohen, O. Why Teach Science to Deaf Children? *Proceedings of the International Conference on Oral Education of the Deaf,* Washington, D.C.: The Volta Bureau, 1967.

Collins, D., and Madden, C. Individualized Project Physics. *The Physics Teacher,* 1974, 12, 465-470.

Fitzgerald, M. Trends in Science Education. *The Volta Review,* 1968, 70, 385-388.

Franklin, A. Physics for Educationally Disadvantaged Students. *American Journal of Physics,* 1973, 41, 3-7.

Friedman, C. A Project to Individualize PSSC. *The Science Teacher, 1976, 43, 15-18.*

Fuller, R., Karplus, R., and Lawson, A. Can Physics Develop Reason? *Physics Today,* 1977, 30, 23-28.

Furth, H. *Thinking Without Language: Psychological Implications of Deafness.* New York: The Free Press, 1966.

Furth, H., and Youniss, J. Thinking in Deaf Adolescents: Language and Formal Operations. *Journal of Communications Disorders,* 1969, 2, 195-202.

Gabe, L. Individualized Learning Can be Structured. *The Physics Teacher,* 1973, 11, 29-32.

Hanner, B. *et al.* Toward the Identification of Educationally Significant Traits of Postsecondary Deaf Students. A Report by the Division of Research and Training (National Technical Institute for the Deaf), 1971.

Lang, H. Teaching Physics to the Deaf. *The Physics Teacher,* 1973, 11, 527-531.

Leitman, A. *Science for Deaf Children.* Washington, D.C.: The Volta Bureau, 1968.

Owsley, P. Teaching Science to Deaf Children. *American Annals of the Deaf,* 1962, 107, 339-342.

Piaget, J. and Inhelder, B. *The Psychology of the Child.* New York: Basic Books, 1969.

Renner, J. and Lawson, A. Piagetian Theory and Instruction in Physics. *The Physics Teacher,* 1973, 11, 165-169.

Smith, J. and Euller, J. An Alternative Plan in High School Physics. *The Physics Teacher,* 1973, 11, 97-102.

Tigranova, L. I. Factors in the Development of Concepts in an Elementary Natural Science Course in Section II of a school for the hard of hearing. *Voprosy spetsial nogo obuchenira slaboslyshchikh detei,* Izvestiia APN RSFSR, Vypusk 139, Moscow: Izd-vo Prosvescheni, 1965.

Titova, M. F. The Deaf Pupil's Knowledge of and Skills in the Natural Sciences. Spetsial, Shkola, 110, 1964.

Tomlinson-Keasey, C. and Kelly, R. The Development of Thought Processes in Deaf Children. *American Annals of the Deaf,* 1974, 119, 693-700.

Walter, G. Performance in English Requires Competence in Syntax and Vocabulary Plus Experience. *Teaching and Learning for Careers* (Teaching Institute Newsletter). Rochester Institute of Technology, 1977.

Science in Sounds

FRANCIS P. COLLEA
Department of Science Education, California State University, Fullerton, California

Innovative projects in the elementary school curriculum have moved away from a complete emphasis on textbooks to incorporate concrete experiences with materials. Many special education people are beginning to see the importance of a materials approach to learning for handicapped children.

Most material developed for "normal" children has limited use with handicapped children. Special education teachers spend hours adapting the materials, reorganizing them into usable lessons for presentation to their classes. The content and philosophy of a particular curriuclum project need not be last.

At a School for the Deaf

Oralingua is an oral/aural day school for hearing impaired. It is a place where children who were born deaf or are severely hard of hearing can learn to talk. The school's philosophy is that deaf children can learn to utilize their residual hearing through the correct selection and consistent use of hearing aids. An active, materials-centered approach to learning characterized the school: an environment that is language-oriented and experienced-based.

About two years ago, Oralingua began using the Science Curriculum Improvement Study (SCIS) in its classrooms. When SCIS was adapted to the needs of deaf children, little of the philosphy, content, and teaching strategies of the program were lost. SCIS provided repetition techniques for learning, listening skills, language expansion, and cognitive development. The SCIS project was easily integrated into the total curriculum of the school.

■

If a program is to be used successfully with deaf children, it should provide for repetition of concepts and words describing them.

The Special Needs

If a program is to be used successfully with deaf children, it should provide for repetition of concepts and words describing them. SCIS provides the special education teacher with a variety of lessons for developing a particular concept with deaf children. For example, in Physical Science Level II, the concepts of "system" and "interaction" can be presented in at least six or seven different ways. For example, magnets, pulleys, springs, rubberbands, and other materials, can be used in new learning situations that develop these concepts. Each time, the teacher can present the same concept with a different learning environment and a completely new set of materials. Each chapter is a SCIS Teacher's Guide contains optional activity sections, presenting the familiar concepts in other new ways. These repetitive activities are essential to the development of a deaf child's comprehension of new language and concepts.

For deaf children, language is most easily attained through real and meaningful experiences.

For deaf children, language is most easily attained through real and meaningful experiences. In the SCIS program, children manipulate and experiment with real objects. In Level I, Physical Science, Material Objects, the children play the Objects Grab-Bag Game, designed to help children identify and group objects by their properties. At least three children use one bag. Each child selects five pieces from the bag without looking into it and puts any two together that are alike in all properties. These pairs are put aside. The game continues, as each child in turn draws a block and returns one to the bag. New Pairs can be made and put aside as additional blocks are taken from the bag. The winner is the first one with all of his or her blocks in pairs.

SCIENCE and CHILDREN 13:6, 34, March 1976

Science Education for the Deaf

Henry Vlug
Model Secondary School for the Deaf, Washington, D.C.

Hearing impaired students comprise a well defined and sizeable group of students. Compared to many of the other handicaps this group has been and continues to be relatively well served by educational programs.

As of October 1, 1976 (American Annals, 1977) there were 44,949 students in 671 schools and classses. These had a total educational staff of 13,793 including 7,743 instuctors. 15,043 (33%) of the students had "residential" status as compared to 29,906 (64%) students with "day" status. 6,008 (13%) were mainstreamed and an additional 7,511 (17%) were partially mainstreamed. 10,859 (24%) of the students were multiply handicapped—i.e. had a handicap in addition to deafness.

Achievement

The shortcomings of standardized tests, especially when used with minority groups such as the deaf, are well known. Still the scores do give some indications of the magnitude of the problems facing teachers of the deaf. The deaf consistently score below their hearing peers on achievement tests. Figures 1-3 (Trybus and Karchemer, 1977 and O.D.S. no date) demonstrate this clearly for three subtests of the Standarized Achievement Test. Reading comprehension is generally agreed to be the most critical area for school achievement for the deaf. Math computation, besides being of obvious relevance, is the area in which hearing impaired children reach their highest test scores. Scaled scores instead of grade levels are used because scaled scores are more appropriate for combining scores across test levels. A scaled score of 132 is equal to or grade equivalent score of 3.2 and a scaled score of 182 is equal a grade equivalent score 8.2. The other scaled scores correspond less closely to grade equivalent scores.

Figure 1 shows that the median (50th Percentile) reading score at its highest point, is 147 (grade equivalent of about 4.5). Thus half the students at any age read less than a mid-fourth grade level. Even the high-achieving group (90th Percentile) reaches only about an 8th grade level. The low-achieving group (10th Percentile) reaches only about a 2nd grade reading level at its

Figure 1: Reading Comprehension Scores National Distribution for Hearing Impaired Students

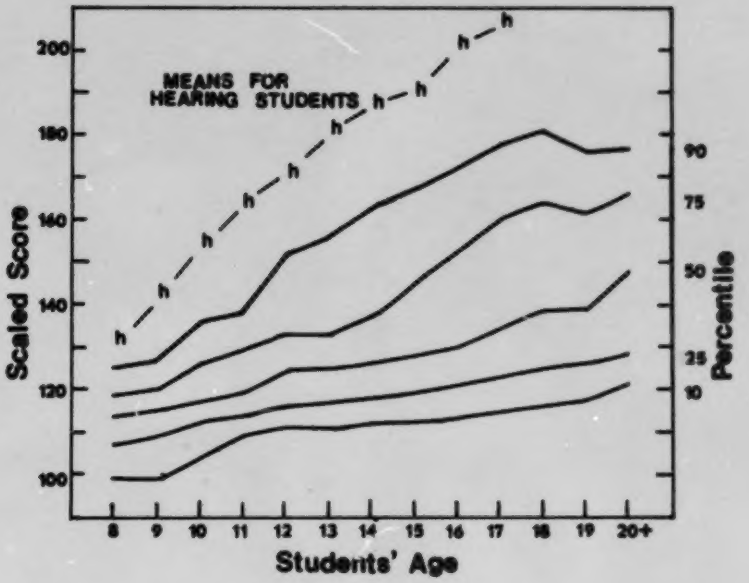


Figure 2: Mathematics Computation Scores National Distribution for Hearing Impaired Students

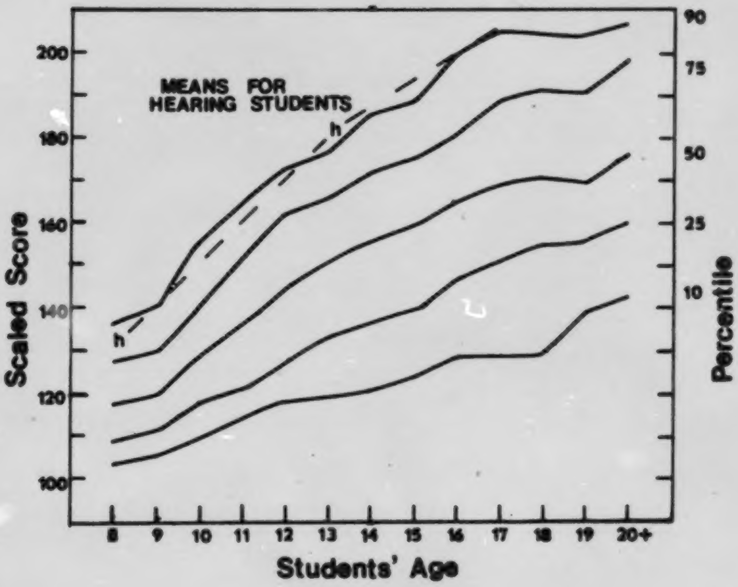
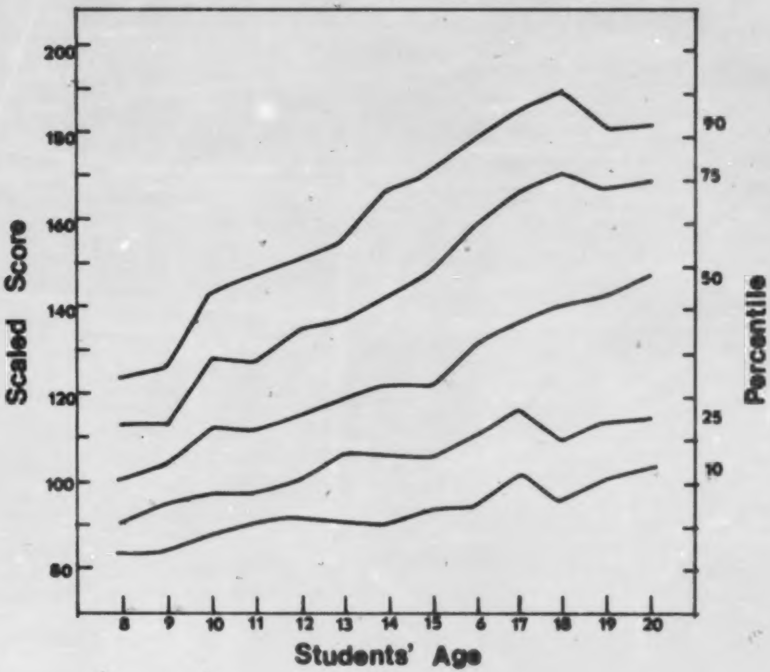


Figure 3: Science Scores National Distribution for Hearing Impaired Students



highest point. In more concrete terms this means that even the high achievers will have difficulty reading science texts written for their hearing peers. When working with low achievers you meet the students who need help spelling "car."

■

In more concrete terms this means that even the high achievers will have difficulty reading science texts written for their hearing peers.

The mathematic computation scores (Fig. 2) are a bit brighter. The high-achievers reach about the same level as the means for hearing students. The median score reaches about a 7th grade level. Even the low-achievers get up to about 4th grade level.

The science subtest scores (Fig. 3) are similar. The high achievers get to the 8th grade level. The median gets up to the 4th grade level. The low-achievers don't go over the 1st grade level.

Deaf Scientists

In spite of the low achievement scores on tests, quite a few deaf people become scientists. While there is no reliable data on the number of deaf scientists there are some indicators. Thus, 6.6% (versus 10.6% for the U.S. population) of 7,920 deaf workers were found to be "professional, technical and similar worker's (Lunde and Bigmen, 1959). However, most (3.6%) of them were teachers. The national census of the deaf found 14.5% in professional and related services industries while 9.2% of the males and 8.1% of the females were classified as being in the professional and technical occupational category (Schein and Delk, 1974). A study of 87 deaf professionals (other than teachers) found 23 to be in Chemistry, 25 in Engineering, 7 in other sciences for a total of 55 (or almost 2/3) (Crammate, 1968). An additional 9 were in Mathematics or Statistics for a total of 64 (or almost 3/4 of the professionals).

Science Curricula

■

Science curricula for deaf students are to a large degree written by individual teachers.

Science curricula for deaf students are to a large degree written by individual teachers (Table 1) (Rosen, et al, 1975). Teachers also have a very large degree of responsibility for curriculum development, textbook choice and sequence of presentation (Table 2). This individual responsibility results in a large number of different programs or textbooks being used (Table 3). The Concepts in Science Series is popular through the 7-8 grade level. Although the survey was made during a time when the use of the new science programs (ESS, ASAPA, SCIS, etc.) developed during the 1960s was near its peak (1972-1973) very few teachers reported using these programs.

Table 1. Sources of Written Science Curricula

Individual teachers independently	67.8%
School	23.9%
City or County	13.9%
State	7.2%
National funded project	7.2%
Total	120.0*

*Total exceeds 100% because respondents reported different sources for different parts of the curricula.

Table 2. Degree of Teacher Responsibility for Curricula

			Responsibility		
Area of responsibility	Number of Respondents	Degree of Total	Substantial	Very slight	None
Curriculum development	183	46.4%	45.4%	6.0%	2.2%
Textbook choice	181	39.8%	39.8%	13.3%	7.2%
Sequence of presentation	187	65.8%	28.9%	3.7%	1.6%

Table 3. Programs and Textbooks Used by Science Teachers

Level	Number of Respondents	Number of Different Programs and Texts	Number of Teacher-Made Programs or Texts	Most Popular Program or Text	
K-3	49	25	5	Concepts in Science	(11)
4-6	55	28	6	Concepts in Science	(11)
7-8	55	39	0	Concepts in Science	(9)
9-10	58	39	4	Modern Biology	(7)
11-12	39	28	2	Pathways in Science Chemistry & Physics	(6)

Science Teacher Qualifications

Table 4 (Rosen, et al., 1975) summarizes some relevant aspects of qualifications of science teachers for the deaf. More than half of the teachers had at least a Masters degree. More than half had taken a science methods teaching course. Less than a quarter had received more than 20 credit hours in undergraduate level science courses. Almost all had some kind of teacher's certificate. Of the 139 respondents who reported having certificates in a content area 34% were certified in science but this is equal to less than 25% of all 195 respondents.

Table 4. Science Teacher Qualifications

Category	Number of Respondents	Percent of Respondents in this Category
Bachelors degree	195	44
Masters degree	195	56
Science method teaching course	195	54
Council on Education of the Deaf certificate	175	49
More than 20 hours in undergraduate science	186	22.5
Some graduate work in science	186	61.5
More than 20 hours in graduate science	120	9
State certificate	195	93
State certificate for science	139	34
State certificate for special education	184	31
State certificate for ed. of hearing impaired	184	70

Model Secondary School for the Deaf (MSSD)

In partial response to the need for leadership in developing curricula (including science) for the deaf, Congress in 1969 established the MSSD. The MSSD is charged with developing and disseminating curriculum materials for the deaf and also with providing instruction for a student population of up to 600 (enrollment in 1977-78 was approximately 170).

MSSD has eight science instructors who are working to meet the charge of development, dissemination, and instruction. MSSD also has a staff of curriculum development and media specialists to assist instructors in their development work. Most of the work of these specialists has gone into areas other than science, partially in response to the lower priority educators of the deaf assign to science (Curtis, 1976; Summers, et. al., 1977).

None of MSSD's science instruction materials are ready for dissemination at this time and there is no indication as to when any materials will be ready for dissemination. There are, however, a large number of courses in various stages of development. Information on MSSD's use of commerically available materials has been published and more is being prepared for publication.

MSSD is using BSCS's (Biological Science Curriculum Study's) two programs that were developed for the mentally retarded—*Me Now* (Grant, 1975) and *Me and My Environment.* The third program in the series *Me in the Future* which BSCS is field testing now was developed with the participation of one of MSSD's science instructors. MSSD's experience with ESS (Elementary Science Study) materials and with BSCS's *Invitations to Discovery* is being prepared for publication.

MSSD has under development courses in Animals, Plant Study, Genetics, Human Biology, Chemistry I "Scientific Procedures," Chemistry II "Physical Properties," Chemistry III "Matter," Chemistry IV "Atomic Theory," Geology, Environmental Studies, Measurement, and Weather. Most of these courses have an "Instructional Package" (IP) format. An IP typically consists of written materials, books, films, equipment, and any other materials that may be needed to complete a lesson.

References

Crammatte, A. B. *Deaf Persons in Professional Employment.* Charles C. Thomas. Springfield, Ill., 1968.

Curtis, J. J. *Educators of the Hearing Impaired Prioritize the Needs for Instructional Materials.* American Annals of the Deaf, 1976; 121(5), 486-488.

Grant, W. D. *Me Now and Me and My Environment: Science for the Exceptional Student.* Science Education, 1975, 59(2), 249-254. A Project to Determine the Feasibility of BSCS's *Me Now* for Hearing-Impaired Student. American Annals of the Deaf, 1975, 120(1), 63-69.

Lunde, A. S. and Bigman, S. K. *Occupational Conditions Among the Deaf.* Gallaudet College, Washington, D.C. 1959.

Office of Demographic Studies (ODS) Stanford Achievement Test, Special Edition for Hearing Impaired Students. Unpublished data.

Rosen, R. F., Roesch, I. H., Beasley, E. E., Higging, F. C. and Lloyd, E. B. *Science Teacher Qualifications and Resources in Schools and Classes for the Hearing Impaired,* United States, 1972-73: Data From a Survey of Science Teachers of the Hearing Impaired. Gallaudet College, Washington, D.C. 1975.

Schein, J. D. and Delk, M. T. *The Deaf Population of the United States.* National Association of the Deaf. Silver Spring, Md. 1974.

Summers, H. D., Rubin, F. S. and Rawlings, B. W. *Selected Statistics on Deaf and Hearing Impaired Students.* Pre College Programs, Gallaudet College 1977.

Tabular Summary of Schools and Classes in the United States, October 1, 1976. American Annals of the Deaf, 1977, 122(2), 138.

Trybus, R. J. and Karchmer, M. A. School Achievement Scores of Hearing Impaired Children: National Data on Achievement Status and Growth Patterns. American Annals of the Deaf, 1977, 122(2), 62-69.

A Lack of Science Education for the Deaf at the Elementary Level

Robert S. Menchel
Office of Career Opportunities, National Technical Institute for the Deaf, Rochester, New York

Serving in the capacity of a role model for the handicapped, the author has been able to observe at first hand the science programs being offered to the deaf in his lecture tour across the nation. Serving in this role model, as well as the fact that the author is deaf himself, has allowed him to speak with the students and the science teachers, unrestricted. Furthermore, the author was a Sr. Physicist with 16 years of work experience and has had over eight years of experience teaching science and math to the deaf at the elementary and college level, so he is quite qualified to evaluate the observed science programs in the schools he has visited. At the time of this writing he has visited 25 schools in ten (10) states.

These observations have shown that at the elementary level and even at the high school level there is a lack of science education in schools for the deaf, both special and public. This lack of the development of a basic science curriculum from kindergarten to the twelfth grade is a national disgrace and one that puts the deaf child at a disadvantage in comparison to the non-handicapped child. Furthermore, deaf students are still being pushed into stereotyped job roles and dead-end jobs. For the female students it is even a worse problem.

This lack of the development of a basic science curriculum from kindergarten to the twelfth grade is a national disgrace and one that puts the deaf child at a disadvantage

. . .

Part of the problem, and the most often used excuse offered by the deaf schools, is that the deaf child needs to spend more time on speech and language development. Hence, science education is pushed aside until the upper grades where it is suddenly introduced without the needed foundation to build upon. This is a false and badly used excuse. There is no reason why science cannot be used to develop vocabulary along with language development.

There is no reason why science cannot be used to develop vocabulary along with language development.

During the author's tour, he found many other problems and excuses being made for the lack of science education for the deaf. However, none of these excuses are acceptable, nor are the problems unsolvable, because it has been found that there are some programs that do offer an equal science curriculum to the deaf student. Furthermore, the author himself has developed and implemented a science program at the Rochester School for the deaf, which is now equal to, and in some cases superior to, science courses being offered in the city's public school.

A Lack of Science Education for the Deaf at the Elementary Level

First let us look at the barriers being placed in the way of the deaf child to avoid teaching them science. Some of the typical excuses brought forth are:

a. Language and speech must be taught first. There is not time for science until high school.

b. Science is too hard for the deaf child.

c. We do not have the equipment and it is too expensive.

d. The daily schedule is fixed, it cannot change to allow a longer laboratory period.

These are but a few of the excuses the author has heard. All of these excuses do not hold up to true facts that have shown that science can and is being taught to the deaf. Going deeper into the problems, we see that the picture is much the same wherever there is a lack of science. Some of these problems are:

a. The teachers are trained in Special Education but lack a science background.

b. The stereotyped idea that science is too hard for the deaf still is present and thus they tend to turn students away from this field.

c. The lack of laboratory equipment and the fact that the teachers do not know how to build low cost equipment or borrow what is needed prevents the much needed and valuable experience of "hands on" science.

d. The poor communication and lack of support in some schools between the science teachers and the administration results in needed information not reaching the science teachers. Furthermore, in some schools the teachers cannot attend workshops to improve their science teaching skills.

e. The lack of knowledge on the part of the teachers about deaf scientists who have been successful in their field, tends to keep the stereotyped ideas in existence.

f. The lack of a flow of information among science techers results in a poor spread of information. Many times a teacher in one school has made up a highly successful science course but this does not reach others because of communication breakdown between the schools for the deaf.

In answer to these problems, the author will show how each of these problems can be solved one way or another. Teachers should have the chance to attend workshops, take courses on science and, if possible, work with a deaf scientist to learn the subject. Science, if started in the early years and built up

157

as the student progresses, is no harder than any other subject. We have found that when presented in a stimulating manner the students enjoy the course very much and look forward to each session.

Laboratory equipment does not have to be expensive. Your imagination and some paper clips, tin cans and rubber bands can teach more than the most expensive piece of equipment, which is kept locked up because of fear of breakage.

The administration must realize that science is not a fixed subject, but one that must be flexible enough to take advantage of what is occurring at a given time. A field trip to get rocks or flowers is as much a learning experience as 45 minutes in the classroom. Laboratory work is invaluable, because a child learns by doing and for the deaf child this is double in its value.

■

Laboratory work is invaluable, because a child learns by doing and for the deaf child this is double in its value.

Some sort of information exchange should be established so that programs can be made available to all schools and not kept secret in one school.

There are many more excuses and problems. What the author has seen shows why the deaf do not enter the field of science in a larger number. They do not because by the time they reach high school grades, they have not had a science education equal to that of a normal child. When we suddenly dump science on them, without the fundamental building blocks, they are turned off. It is too hard, they do not understand it, they do not like it and will find one way or another of avoiding it. Thus, we end up with students who graduate and follow each other into the same careers one after another. Furthermore, the learning of science teaches the child to think in a logical manner that aides in other courses.

The author refuses to accept either the excuses or the problems. There are some outstanding programs in one or two schools that show that science can be learned by the hearing-impaired. In these schools, we have found students who are intersted in entering the field of science.

The Xerox Science Consulting Program and the ESSA program have been used successfully with deaf children. In both cases, the cost of materials is low, because we use the "tin can and rubber band" approach with lots of imagination thrown in.

■

. . . an untapped source of ideas and help . . . This is the deaf scientist in your community who has been successful in his field and who would be able to offer the schools methods . . .

More important, however, is an untapped source of ideas and help. This is the deaf scientist in your community who has been successful in his field and who would be able to offer the schools methods of teaching never thought of before. These people are invaluable, because they have been through the system, and, have overcome the barriers to a science education.

As teachers of the handicapped, you must rethink your methods, forget the stereotyped ideas that have been in existence so long, and turn to those who will be more than willing to offer their advice and service.

6

Science and the Orthopedic Handicapped

6

Science and the Orthopedic Handicapped

Introduction

In general the greatest obstacles for many orthopedic handicapped youngsters in obtaining a meaningful education in an appropriate environment are attitudinal and architectural barriers. Even though these youngsters may appear different outwardly it is erroneous to assume that they are also different inwardly. It is impossible to plan an appropriate educational program with this kind of attitude. For example, some youngsters with mobility problems are not permitted to participate in laboratory type activities even as an observer or a director of the activity. In order for a teacher to respond effectively to the educational needs of a student the teacher must understand the nature of the handicapping condition and the parameters of the student's physical capabilities. In many instances it will only take a little ingenuity on the part of the teacher to enable an orthopedic handicapped student to be an active learner in the science class.

In this chapter a mother of a severely handicapped son identifies a variety of techniques which will enable a handicapped student to participate in the regular science activities. The mother also describes a pilot project in which her son uses a video terminal-computer system to communicate with people. An overview of a support system which a school system uses to provide an appropriate educational program for a variety of health impairments is given. This support system operates in both the elementary and secondary schools. The ways that a school for handicapped students plan for outdoor laboratory type activities illustrates what can be accomplished by a group of creative teachers and students. In the last article the author reviews the function of computer-assisted instruction and emphasizes the potential of this kind of technology in the education of handicapped students.

Adapting Science to Disabled Learners

Judy Hoyt
Association for Support of Human Services, Westfield, Massachusetts

Introduction into the wonders of science in the lives of the handicapped is an exciting concept in any age of our nation's history. It is especially exciting right now because finally with Massachusetts Legislation Chapter 766 and Federal Legislation PL 94-142 handicapped students must be part of our education system. I feel confident no one disagress with the philosophy. Realistically, professionals are apprehensive about the right way in which to deal with the handicapped learner. Educators have questions like what does the disability mean? Will the child break? Will he choke? How do I toilet him? What do I do with the rest of the class while I am involved with the disabled child? How can I get him involved in science experiments? Can he hear and see as well as the rest of the class? How do I maneuver a wheelchair? How can he communicate with me? What do I tell the rest of the class when they ask questions? How much extra time will this student need directly and indirectly in preparing and adapting my lessons? What if there is a fire?

These questions are all very valid and very real. Because our society has excluded the handicapped with attitudinal and architectural barriers for so many years our teacher training institutions of higher learning are just now beginning to realize the need for all teacher trainees to be introduced to the world of the handicapped so they feel comfortable, at least, when they find a small number of handicapped students on their class role.

■

The most important factor to learn in interacting with the physically handicapped is that they are people just like you and I. So what if their body doesn't work when they want it to, they *have learned to live with that problem. They have no choice. We must learn to live with that too and not feel sorry or try to overprotect children because of their differences.*

The most important factor to learn in interacting with the physically handicapped is that they are people just like you and I. So what if their body doesn't work when they want it to, *they* have learned to live with that problem. They have no choice. We must learn to live with that too and not feel sorry or try to overprotect children because of their differences. All of us are different. In some of us, the difference is visable and in others of us, it is not. We all must learn to interact with all people zeroing in on what is inside the artifical outside cover. The functions of the mind and feelings are what we are really all about and maximizing these potentials in the best way possible is where the focus should lie.

In the classroom setting, the purpose of mainstreaming a disabled learner is to make his learning methods approach that of the non-disabled child to the fullest extent possible. Most important in the disabled child's experience is social acceptance by his peer group. We have discovered that children will best accept the disabled learner if his disability is fully understood by the group. Often the best approach is to have a series of lessons on individual differences. Part of this learning experience can include having some non-disabled student becoming "handicapped" by tying fingers together, putting blindfolds on etc. This should also include the teacher. Often students can help these students with a lesson which can be presented while the "handicaps" are applied. Students who are helping the "handicapped" ones should be encouraged to do only as much as is absolutely necessary, allowing the "handicapped" students to do as much as possible for themselves. Once the students have an appreciation that everyone has individual differences, they will have a more positive attitude toward the disabled learner.

■

Most important in the disabled child's experience is social acceptance by his peer group. We have discovered that children will best accept the disabled learner if his disability is fully understood by the group.

Sometimes a science unit can grow out of the experience with a disabled learner. For example, this writer had a child with a severe hearing loss in the room. In a talk with him I discovered that he was most anxious to show his hearing aid to the class and explain how it worked. The class got very interested in the anatomy of the ear, so we called in a hearing specialist who was most helpful.

Any of these experiences will help the class deal intellectually and socially with the disabled learner's differences.

You will encounter many different categories of physical handicaps. Whether the law followed in your school is setting labels on children or not is not really important. You, as a teacher, must know the disability you are dealing with in order to plan proper interaction of the child within your classroom setting. The wheelchair table of a spastic cerebral palsy child would not be the place to set glass beakers for an experiment. The uncontrollable flailing movements of a spastic child would probably unintentionally knock off the beaker. Discussing the placement of a science experiment in relations to a spastic learner is an excellent lead in for the disabled child and the rest of the class to talk about why the child cannot control his arms. You as a teacher will have to have done your homework to be ready to focus the discussion in the proper direction. It is very healthy for disabled people to talk about what they can do and why they cannot do other things and how they compensate for what they cannot do. Able children learn to accept all of life's trials and tribulations much easier when they have had the experience of interacting with someone who has had to cope with life in a different way than they have.

■

It is very healthy for disabled people to talk about what they can do and why they cannot do other things and how they compensate for what they cannot do.

Architectural barriers (the physical things in the school building and classroom) can be worked around. If a science class must go to the second floor in a building with no elevator, then a couple of teachers or older students should simply carry the non-ambulatory child to the setting. A matter of fact attitude in dealing with mobility usually forces us to use common sense to adapt to a situation.

Some of the children you may deal with in the classroom may be mildly impaired and have varied ability in fine motor skills. They may move slowly or jerkily and easily lose their balance. Many will drool and have slurred or non-intelligible speech. Canes, crutches, walkers and wheelchairs will become commonplace to you with some of these children. Remember to allow your disabled learner to share his apparatus with the able children. This is an important part of acceptance. The very disabled children may have a classroom aide with them and some type of communication device. Remember to talk directly to the child, not to the child through the aide. Ask a child with poor speech to repeat what he is trying to say as many times as necessary. He knows he is hard to understand. Make use of body language and encourage classmates to interpret for the learner. When it is necessary to lift a child, lift with your knees, not your back. Some of the mobility impaired disabilities you might encounter are cerebral palsy, spina bifida, arthro groposis, muscular dystrophy, scoliosis, spinal cord injury, leg prosthesis disease, asthma and rheumatoid arthritis.

■

The very disabled children may have a classroom aide with them and some type of communication device. Remember to talk directly to the child, not to the child through the aide.

Deaf children are leaving specialized settings more and more and returning to the mainstream. Make sure the deaf learner sits where he can see to read your lips. Encourage him to use his hearing aid when he has one. Blind children are trained when very young to organize in a clockwise direction. Keep this in mind when you are teaching.

All disabled people highly develop the senses they have command of to compensate for what is lost. They also develop body language and will pull all the tricks of the trade every other child in your classroom will try.

Keep in mind the sensory apparatus is sometimes lost in certain disabilities. For example, when attaching a magnet to a child's body so he can feel the pull, don't attach it to his leg if he has no feeling there. Remember too that many disabled children, because of their overprotective families, have not experienced some of the sensations we take for granted. These sensations can be experienced by your whole class by venturing outside of the class to the grass, or sand. Encourage all the children to roll and slide and appreciate the laws of science at work in our environment at all times. This will mean getting a child out of his wheelchair and unlocking braces in many instances. Feeling and in doing learning principles is much more meaningful than being told something feels a particular way.

Pairing of classmates so that all in the class get to be a partner to the learner needing help is also important. Many of the quiet classroom learners will be too shy to step forward and interact with a child that is different. Be sure to watch for a child who might have a very difficult time relating to the disabled learner. Talk out any of these feelings and let the child know it is okay.

When planning a trip outside the school setting, make it second nature to inquire as to accessibility of the building and toilet facilities. Also inquire about braille for the blind students.

■

When planning a trip outside the school setting, make it second nature to inquire as to accessibility of the building and toilet facilities.

A suggested planning process is to begin the year with a notice going home to all the parents talking about the overall goals and talking about the pairing and experiencing for all the children in the area of individual differences.

When planning your lessons, it is important to pair students as much as possible and assume that all your class has had limited sensory stimulation.

When presenting a science lesson to a class which includes handicapped students, the teacher should attempt to utilize the child's well-developed sensory channels.

A lesson on magnetic models from level 6 Science Curriculum Improvement Study, SCIS, Chapter 8 guides the student to explore the interaction of different materials with a magnet. The students are asked to make a list of materials that interact with a magnet and those that do not.

We can adapt such a lesson to a spastic child who has no limb control by taping the magnet to his hand or arm. Another student can bring objects in contact with the magnets. The child should be able to feel and see which objects interact with the magnet and which do not. In this way, the spastic child is involved in the decision making and discovery that is the major emphasis of the lesson.

Another lesson in Astronomy involving the cause of day and night and the rotation of the earth can be taught to the blind student with the use of a heat lamp. The student turns (counter clockwise as the earth does) while a heat lamp is directed toward him. The heat lamp represents the sun. Here the teachers utilizes the input channel most closely related to light that the child can utilize.

When teaching a lesson on revolution of the earth around the sun, a student confined to a wheelchair can be wheeled around in a circle along with the other students who will take the paths of other planets.

■

Once a teacher is "tuned in" to adapting lessons to the handicapped, many novel methods become evident.

Once a teacher is "tuned in" to adapting lessons to the handicapped, many novel methods become evident. Students also sometimes come up with useful ideas and should be encouraged to do so. Sometimes the adaptation helps all the students gain a greater understanding of the objectives of the lesson.

Disabled children grow up and as society conquers some of its barriers aides in museums and planetariums will be needed to initiate displays and allow the disabled to enjoy the shows as everyone else does.

A significant part of the educational experience occurs outside the classroom. Field trips to museums, planetariums and performances may present problems to disabled learners. Adaptation must be extended to these areas.

Perhaps the first problem encountered by the disabled learner is the presence of architectural barriers. A call to the museum, etc. should be made to determine if the building is accessible. If not, the teacher should show concern and perhaps point out the availability of funds to remove barriers.

Many museums have changed or are in the process of changing to interactive displays. The visitor to the museum pushes a button which activates a series of demonstrations or a recording. This type of exhibit can be adapted to the disabled learner by installing an ultrasonic switch in parallel with the button. The museum supplies an ultrasonic sound device which can be attached to the wheelchair and activated by a standard input jack from the disabled learner's switch. The device would be very directional and of limited range so that only one display would be activated at a time. At first glance, a planetarium show would not seem to present any more problems than a movie theater. However it is projected directly ahead while the planetarium show is projected in many directions including overhead. This may pose a problem for someone who is confined to a wheelchair and has restricted head movements. Rather than provide a complicated and perhaps intimidating device which would provide both side-to-side and up or down movement, we propose a much simpler apparatus. A rotating platform (no bigger in area than the wheelchair itself). This would provide the side-to-side movement while prism glasses could be used to provide a wider vertical field of view.

The writers are presently working on such a device as a pilot project and hope to make it available to the Springfield Museum of Science in Springfield, Massachusetts in the near future.

■

We live in an age of electronic wonders. This is very exciting and beneficial to the disabled. The use of computer technology to communicate with disabled learners will depend on how much of a communication problem the person has.

We live in an age of electronic wonders. This is very exciting and beneficial to the disabled. The use of computer technology to communicate with disabled learners will depend on how much of a communication problem the person has. If the disabled learner is able to type on a computer key board, then he may need special software. Also, if the person has muscular problems and is able to control a switch, then he should have the use of special software and mechanical devices. This section will discuss the cost and efficiency of microcomputers to communicate with the disabled learners, a computer system and software that is a disabled learner is using, and specific details about the kinds of software that can be used with physically disabled learners.

In the United States there are several dozen computer manufacturers with a new one coming out every month or so. Almost all of these manufacturers have a good micro-computer that is inexpensive and has a way of keeping storage, either by a floppy desk, cassette, paper tape or some other form. Special software for the handicapped can be stored on these devices until needed. When somebody needs the software, all they have to do is call the program to memory from the floppy desk, cassette or whatever kind of storage they have. Also, the cost of micro-computers is relatively low and is expected to decrease in the foreseeable future.

The software being used by Rick Hoyt, a severely physically disabled learner in public school in Westfield, Massachusetts, is used for the Digital VT 52 video terminal which is to be used with the Digital PDP 11/50 computer. One piece of software will print out eight (8) groups of letters, numbers, and words. After the computer prints out the words, a cursor will go next to the groups of words for the number of seconds specified in the program.

When Rick sees the cursor next to the group that has the letter in it that he wants, he will hit a switch[1] or hit the escape (altimode)[2] button on the computer terminal. If he does not want that group of words, the cursor will automatically go to the next group of words and do the same thing over again. After the cursor goes through all the groups of letters, numbers and words the computer will start all over again at the first group of words. After he hits the switch, the computer will then print out the group of words on the top of the screen. After that, a cursor will go under the letter or word for the number of seconds specified in the program. When he sees the letter or words that he wants, he hits the switch. If he does not want that letter or word, the cursor will then move to the next letter and start all over again. After the cursor goes through all the letters or numbers in that group, the computer will clear the line and go back to ask for what group of letters or words he wants. After he hits the switch for the letter he wants, the cursor will go on the very top line on the screen and wait the number of seconds specified in the program. If Rick hits his switch during this time the computer will think that Rick does not want that letter or words and will then go down at the bottom of the screen and start asking for the group that he wants. But, if he does not hit the switch the computer will print out the letter or word with the other letters and words that he picked previously. After that, the computer will go back to ask for what group of letters or words that he wants. When Rick exits from the program, the computer will store all the letters, numbers and words in a file. If anyone wishes to see the letters, numbers or words Rick has used, all that must be done is to use another program which will print out the letters, numbers and words and how many times Rick has used them. This information can be used to analyze the word usage and patterns of the student. Computer technology is a flexible way for the physically disabled to communicate.

A unique group of individuals, most of whom recently have had their lives affected by their involvement with a severely physically disabled nonvocal learner, came together to produce this paper. The sharing, sensitivity and growing that occurs when people pull together resources and common sense to teach science and use science to better the lives of the disabled is a wonderful event.

■

The sharing, sensitivity and growing that occurs when people pull together resources and common sense to teach science and use science to better the lives of the disabled is a wonderful event.

This paper was prepared by the following people: Tod Emmershy, 10th grade able student; Rich Hoyt, 7th grade disabled student; Joseph Wright, 6th grade science teacher; Peter Backus, graduate student; Judy Hoyt, mother of physically disabled student; Richard Warren, bio-medical engineer.

---

[1] *If a person using this program is physically handicapped, a switch will be used to trigger off the escape (altimode) button.*

[2] *The escape (altimode) button on the computer terminal is a character that was chosen in this program.*

Bibliography

The Instructor Magazine, October 1977, pg. 202-203, "Ricks's A Part of the Team," talks about mainstreaming a multiple handicapped, non-vocal child with the use of an electronic communicator.

Computer Software, Interactive Communicator Software Using Morse Code. MCode LPT by Robert P. McCormick, % Wilfred Pacquin, Westfield High School, Computer Center, Westfield, Massachusetts.

R-1074 Progress Report, A Research Program for the physically handicapped to develop independence via "Build-It-Yourself-Kits" and practical instructions in engineering technology by Richard E. Warren, April, 1977. The Charles Stark Draper Laboratory, Inc., Cambridge, Massachusetts 02139.

Science Curriculum Improvement Study, *Models: Electric and Magnetic Interactions,* Rand McNally and Company, New York, New York, 1971.

Science Education for the Physically Handicapped Student: "Support" Model

Noel G. Thornburg
Montgomery County/Public Schools, Silver Spring, Maryland

Introduction

Science education for approximately one hundred students in the Programs for Physically Handicapped Students in Montgomery County Public Schools (MCPS) is based on a "support" systems model. Students attend regular community elementary, junior high, or senior high schools. Their support comes from regular teachers, special teachers (trained to work with physically handicapped students), therapists, student and adult volunteers. The professional participation in the support system is inversely proportionate to the age of the student.

The disabilities represented in the physically handicapped population are results of: spina bifida, cerebral palsy, muscular dystrophy, other dystrophies, atrophies, osteogenesis imperfecta, tumors, cerebral vascular accidents, sickle cell anemia, amputations, Ataxia telangiectasis, Emidermolysis bullosa, and other health impairing conditions.

Elementary Program

Three hundred forty-four students attend Forest Knolls Elementary School. The twenty teachers and nine aides strive to emphasize the one-school concept, but some of the Forest Knolls students are obviously different. Using wheelchairs, braces, crutches, and canes to move from class to class, sixty percent of the physically handicapped students are mainstreamed into some regular classes. The remaining forty percent have their classes with special teachers who present academic challenges by special teaching strategies.

> *The school has an adapted playground, bus loading ramps, wide doors to accomodate wheelchairs, hand rails in halls and restrooms, changing areas in rest rooms, . . .*

Although the facility was designed with consideration for the young physically handicapped student, the one-story building and grounds are undergoing constant modification to allow maximum involvement of all students. The school has an adapted playground, bus loading ramps, wide doors to accomodate wheelchairs, hand rails in halls and restrooms, changing areas in restrooms, plus special areas for physical therapy, occupational therapy, and speech therapy.

The science curriculum (end of article) is taught by both regular and special teachers. The support necessary for the physically handicapped student is determined by the teacher, physical, occupational, and speech therapists, nurse, and student. The source of the support may be the regular teacher, (depending on the comfort level of that teacher), the special teacher, an aide, or another student. The actual support may be in the form of assistance in getting to class, helping to locate or prepare class material, copying or providing class notes, etc.

The teacher becomes the primary manager of the support and determines with the student(s):

(1) What support is actually necessary?

(2) Can the student arrange for the support?

(3) Should the teacher arrange for the support?

Junior High Program

Seven hundred twenty-two students attend Col. E. Brooke Lee Junior High School. Nineteen are physically handicapped with physical profiles similar to those reflected in the elementary school population. Sixty percent of the students in the physically handicapped population are mainstreamed into some regular classes.

Some architectural modifications have been made to the two-story elevator building housing the program.

An extra curricular club, organized to provide a social arena for physically handicapped and able-bodied students, allows the handicapped students to develop expertise in designing their own support system incorporating their able-bodied peers, in addition to teachers, aides, therapists, or parents.

The science curriculum (end of article) is taught by both regular and special teachers. The support necessary for the physically handicapped student at this level is determined by the teacher, physical therapist, counselor, or student. The actual support may come from the regular teacher, (depending on the comfort level of that teacher) the special teacher, an aide, nurse, or another student. It may include pushing to/from class, library, cafeteria, etc., carrying materials, preparing class materials, using cassette recorders or Notetakers,[1] copying notes, studying with the student or actually tutoring, assisting in carrying for personal needs in cafeteria, restroom, etc.

An extra curricular club, organized to provide a social arena for physically handicapped and able-bodied students, allows the handicapped students to develop expertise in designing their own support system incorporating their able-bodied peers, in addition to teachers, aides, therapists, or parents. The physically handicapped student in this setting begins to assume the responsibility of primary manager of his/her own support system.

---

[1] *Notetakers are loose-leaf notebooks of NCR paper commercially available from the Bookstore, Rochester Institute of Technology, #1, Lomb Memorial Drive, Rochester, New York.*

Senior High Program

One thousand sixty-six students attend John F. Kennedy Senior High School. Twenty are physically handicapped with physical profiles similar to those reflected in the elementary population. Fifty percent of the students in the physically handicapped population are mainstreamed into some regular classes.

Some architectural modifications have been made to the two-story elevator building housing the program.

The science curriculum (end of article) is taught by regular teachers. The support necessary for the physically handicapped student at this level is determined by the teacher, physical therapist, counselor, and student. The actual support may come from the regular teacher (depending of the comfort level of that teacher), the special teacher, an aide, nurse, or another student.

■

The management of the support system in senior high school is directed by the student.

The management of the support system in senior high school is directed by the student. Successes and failures of systems on the junior high level determine what kinds of things work best for the student. The special staff is of course available for conference and actual support when indicated, but the student is responsible for developing the system. This design affords the student the opportunity to explore and develop the best support system for him/her. The management experience is an important one for the high school physically handicapped student if s/he is to function independently in college or in a work situation.

In addition to the Montgomery County Public School Science Course of Study, physically handicapped students are participating in Project Uncover. Funded by the National Science Foundation, Handicapped in Science Programs, directed by MCPS, the project compares the career possibilities in archeology for the handicapped high school student compared to those of the able-bodied student. Twenty-four students (twelve handicapped and twelve able-bodied) will participate in two pre-dig seminars, two week archeological field school in the Shenandoah Valley, Virginia and a post-dig seminar. The final report of this study is available.

Science Program of Studies

Montgomery County Public Schools

A. Kindergarten
   1. Force and Motion
   2. Properties of Matter
   3. Environmental Differences
   4. Needs and Processes of Living Things

B. Grade 1
   1. Forms of Energy
   2. Forms of Matter
   3. Effect of Environment on Living Things
   4. Reproduction
   5. Forms of Life
   6. Earth and Daily Changes

C. Grade 2
   1. Energy Changes
   2. Matter and Motion
   3. Environmental Conditions for Life
   4. Life Cycles
   5. Extinct Life
   6. Movement of Earth and Moon

D. Grade 3
   1. Radiant Energy
   2. Structure of Matter
   3. Environments and Related Living Forms
   4. Classification of Living Things
   5. Environmental Changes
   6. Solar Systems and Changes

E. Grade 4
   1. Energy and Motion
   2. Chemical Changes
   3. Exchange Between Living Things and Environment
   4. Environment and Reproduction
   5. Living Things and Environmental Changes
   6. Celestial Bodies and Motion

F. Grade 5
   1. Energy, Force, and Motion
   2. Conservation of Matter

3. Green Plants and Radiant Energy
4. Cells
5. Living Things and Time
6. Celestial Bodies and Change

G. Grade 6

1. Energy Systems
2. Matter and Energy in Nuclear Reactions
3. Adaptations of Living Things
4. Genetics and Characteristics
5. Genetics and Change
6. Radiant Energy of Stars

H. Grade 7 (General Science)

1. Life Science
2. Drug Education

I. Grade 8 (General Science)

1. Earth Science
2. Physical Science

J. Grade 9 (Laboratory Science)

1. Physical Measurement
2. Force, Motion, and Simple Machines
3. Basic Inorganic Chemistry
4. Basic Organic Chemistry
5. Environmental Studies

K. Grades 10 through 12

1. Biology
2. Advanced Biology
3. Horticulture
4. Environmental Science
5. Physical Science
6. Vocational Science
7. Earth Science
8. Applied Science
9. Chemistry
10. Advanced Chemistry
11. Physics
12. Advanced Physics
13. Advanced Physical Science

Laboratory-Based Mathematics and Science for the Handicapped Child

Thomas R. Post
Mathematics Education,
University of Minnesota,
Minneapolis, Minnesota
Alan H. Humphreys
Science Education,
University of Minnesota,
Minneapolis, Minnesota
Mickey Pearson
Michael Dowling School for the Handicapped,
Minneapolis, Minnesota

It seems clear that all children, handicapped and nonhandicapped, learn from their own experiences and from direct interaction with their peers and adults. Laboratoy-based experiences incorporate these basic components needed for effective learning. If one accepts the premise that a handicapped student has needs similar to those of other children, and that such a student develops concepts as others do, it then follows that these young people should be included whenever and wherever possible in all scheduled activities.

A handicap does not necessarily imply impairment in learning ability, only an inability to receive information through the impaired receptor. Often the constraints imposed by the particular handicap will necessitate a modification, rather than elimination, of these experiences.

Handicapped in the Classroom

The classroom teacher needs to be aware of the level of intellectual functioning of each handicapped child so that appropriate experiences may be provided. Since children differ in their rate of mental development(3) and in their interests and special needs, many different learning experiences need to be available at any given time. An environmental laboratory can be designed and equipped to anticipate and accommodate vast differences between individuals.

Questions arise when planning a laboratory-based program. How does one provide for an informal atmosphere in the classroom? How can responsibility for learning be shifted from teacher to student? How much should classroom furniture be rearranged to facilitate the laboratory approach? What kind of materials are needed? What practical suggestions are there to help assure success during the crucial early stages? Some guidelines which have been useful to the classroom teachers of handicapped and nonhandicapped children include:

a. Select learning experiences which promote active student involvement,

b. Believe in the intellectual capability of students and plan instruction accordingly,

c. Function to facilitate learning,

d. Recognize the importance of the "why" as well as the "how,"

e. De-emphasize exposition while promoting student discovery,

f. Encourage student hypotheses (guesses) and their subsequent evaluation,

g. Encourage and reward divergent student responses (creative thinking),

h. Promote continuous classroom interaction (student to student and teacher to student),

i. Continually promote genuine problem-solving activities, and

j. Recognize the importance of the process as well as the product of learning.(5)

Handicapped children, as much as possible, should be involved in laboratory-based science and mathematics activities. Mathematics and science textbooks by their very nature must approach content material at what Bruner has called the iconic and/or symbolic levels of representational thought. (2) (Pictures and symbols respectively.) These activities can be presented first at the enactive level (hands-on experiences). Instead of having students read about another's actions and analyze someone else's data, the teacher can rewrite or reconstruct "story problems" provided by any textbook, so that students are actually involved in the physical setting described in the problem. Students will then be experimenting and analyzing results which are more relevant to them since they are actually involved in the process of generating those data.

■

Students will then be experimenting and analyzing results which are more relevant to them since they are actually involved in the process of generating those data.

For example, rather than asking children to make a graph from the data given in the accompanying table, why not use a centimeter tape and measure the head spans of children in class, then construct a graph of the relative sizes of the head spans? Each child has now made a "real" contribution to the class activity. The children are involved with basically the same mathematics (or science); it is the initial delivery system which differs.

Before detailing a science and/or mathematical situation to transform it into a laboratory experience, there are other suggestions:

1. Be sure that directions and questions to students are concise and clear. If students are to proceed with a minimal amount of teacher input they must know precisely what is expected of them.

2. All students should be given the needed materials for the laboratory lesson or provided with a simple description of how they can be obtained.

3. If equipment needs to be assembled, be sure to include appropriate instructions and/or assistance in its assembly.

4. The constraints imposed by individual handicaps must be kept continually in mind in designing laboratory activities. Otherwise the experience could discourage and perhaps even humiliate children. For example, children in wheelchairs could not relate very well to a problem in which body weight histogram of class members is required.

A School for the Handicapped

The program at the Michael Dowling School for handicapped children in Minneapolis provides an example of an ongoing outdoor learning laboratory which has been designed specifically for children with various physical handicaps. During a visit, you might find some youngsters rolling in a pile of leaves, some wiggling their toes in a shallow pond, and some just relaxing in the warm sunshine. These are important sensory bits of information in every child's life. What is different here is that the child in the pile of leaves wears metal braces and the children in the sunshine are in wheelchairs.

■

Pocket gardens have been built along paths. By using a frame made of logs, the gardens are high enough so that children in wheelchairs can tend them.

Teachers, parents, and students of the school have transformed the playground, natural areas near and around the school, and a nearby park into a multi-use outdoor learning area. Pocket gardens have been built along paths. By using a frame made of logs, the gardens are high enough so that children in wheelchairs can tend them. Three or four discarded tires elevate a strawberry bed. There is a large pond constructed by children from Michael Dowling and neighboring schools. Winding asphalt pathways afford wheelchair access to small groves of trees and meadow areas where wildflowers and insects abound.

"Hands-on" science and mathematics units have been designed to make use of the site. In winter, children dig caves in the snow, crawl inside, and measure temperatures. They discover that snow is an insulating blanket for plants, wintering insects, and rodents.

Garden plots are equipped with thermometers and rain gauges so that children can keep track of climatic as well as growth changes from season to season.

Examining what happens when hundreds of bits of brown, green, yellow, red, and white construction paper are sprinkled over a 5 x 5 meter area helps children to develop some understanding about camouflage, especially if they are given five minutes to find all the colored pieces they can. The game helps develop eye-hand coordination. Histograms showing how many pieces of each color can be used to illustrate selection and survival principles.

For another activity utilizing the senses, a teacher smears an onion on posts and tree trunks. The odor provides cues for "wild game" in which the secret trail leads to a surprise. Variations include bits of paper sprinkled along the trail or several hidden tape recorders emitting sound "cues."

The handicapped children at Michael Dowling have one or more physical or mental problems which may interfere with their ability to learn in a traditional classroom. Each teacher must plan a variety of activities, allowing for acquisition of information by alternate pathways, e.g., auditory, tactile, olfactory. Also, two or three children judiciously grouped for an activity can help and support each other.

■

Children understand that a physical handicap does not imply an impairment in learning ability. One little girl ingeniously marked the tire of her wheelchair so it worked like a trundle wheel and she was promptly elected captain of the playground measuring team.

Children understand that a physical handicap does not imply an impairment in learning ability. One little girl ingeniously marked the tire of her wheelchair so it worked like a trundle wheel and she was promptly elected captain of the playground measuring team. Love, patience, and ingenuity by the teacher can minimize the effects of the disability and serve to equalize learning opportunity, potential, and acquisition.

Conclusion

A laboratory approach to science for the handicapped can be a refreshing change for both the teacher and students. Introduce a modest number of laboratory experiences at first. This will give everyone concerned an opportunity to adjust to the new classroom atmosphere and instructional setting. The first attempts should be structured so that students know precisely what is expected of them. As they become more comfortable in the laboratory setting, activities can become more diversified and less structured.

References

1. Adler, Irving. "Mental Growth and the Art of Teaching." *The Arithmetic Teacher* 13:576-84; November 1966.

2. Bruner, Jerome. *Toward A Theory of Instruction.* W.W. Norton and Company, New York City 1966.

3. Furth, Hans G. *Piaget and Knowledge.* Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1969.

4. Ginsberg, H., and S. Opper. *Piaget's Theory of Intellectual Development.* Prentice Hall, Inc., Englewood Cliffs, New Jersey. 1969.

5. Reys, R., and T. Post. *The Mathematics Laboratory: Theory to Practice.* Prindle Weber and Schmidt, Inc., Boston, Massachusetts. 1973.

Science and Children, *13:6, 41-43, March 1976.*

Computer Assistance for Physically Handicapped Students

Jerrol Windbigler
Maine South High School,
Park Ridge, Illinois

For a number of years computer proponents have extolled computer-assisted-instruction as being revolutionary education. In that regard the almost messianic enthusiasm of the computer zealots has been easily matched by the apathy and resistance of the non-zealots to the introduction of the new technology. It is not hard to understand why the revolution has not been widely recognized. There are so many technical innovations with each having its own proponents, that workers in any given field find it difficult to keep abreast of developments. Teaching has born the brunt of the population explosion and the teacher hasn't had time to be aware of all the technical breakthroughs. As an example of an earlier innovation one could consider the reaction of educators as they were first introduced to the use of movies in the classroom setting. There were probably many who embraced the new system as the ultimate weapon against ignorance; others probably just as actively rejected it as being of little or no use or opposed it as being "de-humanizing"; while the majority either ignored it or used it as appropriate and available for their purposes. So it is and will be with computers. Many of us are zealots for or against computer usage, while the vast majority know not, care not, or are just waiting while the revolution takes place. It is the purpose of this paper to indicate to a limited degree an application of technology to the educational nurture of physically handicapped students.

The greatest handicap a teacher faces is that of time that can be effectively spent with each student. In that regard computer-assisted-instruction, CAI, is a time dilator.

Computer systems are unique to education as an extension of the teacher to teacher contact. The greatest handicap a teacher faces is that of time that can be effectively spent with each student. In that regard computer-assisted-instruction, CAI, is a time dilator. CAI allows us to give personalized teacher help to the student for as long as the student desires or needs it. It extends the teacher, time-wise, to the student without over-extension of the teacher's time and patience and without deprivation of other students' access to the teacher. The beauty of the system is that it is easily available at home in the school at relatively low cost and with few restriction or restraints.

Another advantage of CAI is the personal touches which can be built into the program. Each student should and can be treated individually both in content and in evaluation. From the use of familiar phraseology, sayings, even nicknames used by the teacher in the computer program each student is assured that the teacher is indeed there helping whether the setting is the home, the school, or even a hospital. Specific areas of interest or need can be emphasized for student use when the appropriate time is presented. Thus, the student works in areas of personal interest and/or need with a familiar "voice" on call for instant help.

Considering the richness and variety of educational stimuli and the fact that many experiences could not be presented by any other means, CAI must be considered an innovative improvement and an asset to quality *education.*

As will be noted later certain learning experiences can not be presented in any other way than the computer. This is an advantage not totally recognized or accepted by teachers until they've used CAI. Added to these advantages mentioned is the wide variety of learning experiences available in CAI. Considering the richness and variety of educational stimuli and the fact that many experiences could not be presented by any other means, CAI must be considered an innovative improvement and an asset to *quality* education. For a variety of reasons but primarily due to improved technology; the cost per pupil has now become a positive factor for utilization of CAI. In effect, with the advent of this "new" technology we have at our fingertips a cheap but effective delivery system for tutorial teaching on a grand scale; we need but understand it better and use our imaginations more for complete application to the needs of our children in need of education. There are two terms which one should know for a better understanding of computer systems. The first term we should develop is that of *hardware* and the other term is *software.*

Fortunately, it is not necessary to understand the mechanics or electronics of computer systems in order to make use of them. It is analogous to driving an automobile.

Hardware is, simply, the electrical and machinery part of the computer systems. In conjunction with programs, cards, data, and files which are referred to as *software,* hardware comprises the total computer system. In general, people seem to be most impressed and even fearful of the machine part of the computer system but both aspects are necessary for the total system to run. Fortunately, it is not necessary to understand the mechanics or electronics of computer systems in order to make use of them. It is analogous to driving an automobile. Certainly some people who drive cars are mechanics and can repair them if the need arises, but the vast majority get by with as little knowledge as possible and still enjoy the benefits of the auto. For the purpose of this discussion hardware can be examined from three areas of usage: accessing, storage, and operation.

When accessing a computer, a user somehow connects to and communicates either responses or commands to the computer. Thus, in this discussion input and output are considered as part of accessing the computer. Storage is the library facility a computer system has for data, files, and programs. Operation means the electronic and mechanical processes the system undergoes upon command of the operator or user. Two "sizes" of computers are pertinent in this paper regarding the use of computers in teaching: micro and mini computer systems.

As the name implies, microcomputers, are much smaller than the larger institutional style computers we ordinarily think of when the word is used. Miniaturization has extended the scope, storage, and operational capabilities of the micros until they are appropriate and feasible for educational and small business usage. Accessing a microcomputer means turning on a couple of switches and typing in a command for a program-lesson. The video display can in many cases be the home TV set with a suitable RF coupler. The computer is housed in the base of what appears to be a small electric typewriter. Microcomputers for home usage and small businesses are available on the open market now for about $500.

The next larger size and capability is the minicomputer. Using automobile analogy a microcomputer would be a sub-compact, while the minicomputer would be a compact; that is a Ford Pinto compared to the Granada. In most cases owning a minicomputer isn't economically feasible for smaller school districts or even moderate-sized ones for that matter, so a system called time-sharing has evolved. Time-sharing offers maximum capability to the user with the lowest cost at some loss in flexibility. In this mode many users share the computer's costs and its time. Since the operations a computer performs only requires billionths of seconds, many users can be served simultaneously with little loss of convenience and a great increase in computer usage efficiency. The computer is kept at an external site and the users access it with a telephone connecting the computer through an accoustic coupler to the user's keyboard. Again, output can be by a video tube or by printing on paper. For our purposes the student could be supplied with the coupler, keyboard, and video tube to utilize the central computer facility. Some school districts in the Chicago area already allow students to access their computers from home for personel use. It should be pointed out that the typewriter-like keyboards and accoustic couplers can be rented from computer services, who also maintain and service the equipment. The cost of such services varies widely depending upon the services rendered as well as upon the locale. The terminals used by the writer costs less than $1.50 per hour on a yearly basis figured on the number of students using it and a six hour day. Requesting a particular program by typing in a special name the student could obtain each lesson or course of study assigned and could progress at his own rate until in-school instruction or until further teacher contact was resumed.

Software is the name given non-electronic or non-mechanical portions of computer systems. It could be punched cards or paper tape "read" into the computer to store data, names, files, or programs in the system library. By program, of course, is meant the series of commands given the computer in a special format and procedure in order for it to perform a specific task or tasks. There are already many programs (thousands?) written for specific areas of science. There have not been that many written for the kind of program envisioned in this paper. The kinds of programs which have already been found useful in teaching can be listed under one of the following general titles: simulations, games, drill, testing, individual problems and/or questions. The list is not complete but a discussion of these should clarify the uses a computer might have to a teacher of handicapped students.

■

There are already many programs (thousands?) written for specific areas of science. There have not been that many written for the kind of program envisioned in this paper.

Simulation involves informing the student of a phenomenon or experiment and by suitable steps have the student seek an explanation, which explains data given as the experiment proceeds. It is similar to a "thought" experiment except appropriate data (including extraneous points) is provided as the experiment proceeds. An example of a simulation is one available on both mini[1] and micro[2] computers for an experiment with fruit flies. As you can imagine, an experiment with flies involving generations of a particular genus would be time-consuming as well as messy. The program, DROS,[2] is one in which genetic characteristics of the offspring of a pair of Drosphilia flies with specified traits are determined for a number of generations. Different genotypes can also be selected. Like most computer interactives the simulated experiment can be run as often as the students want to until understanding is assured. It has built into it a guessing detractor, so that if the student doesn't have any idea what is going on he is referred to further study. This happened to the writer, who is weak in Biology.

■

LEM, written for a microcomputer lets the student simulate landing safely on the surface of the moon with an escape module.

Games as the name implies are educational but are game-like in their format. There are games also, which are purely recreational, but these are not the ones under consideration in this paper. LEM, written for a microcomputer lets the student simulate landing safely on the surface of the moon with an escape module. The conditions of approaching the surface are given the student continuously on the video display and he must type commands to adjust velocity and direction for the soft landing. Computer games are popular with students and most systems have certain hours available for them or the system would be overloaded with game-players!

Drill programs are the best known and the easiest CAI software to develop. They can be lengthy or brief depending upon the particular concepts and/or student(s) involved. An example of a drill program for the minicomputer is FORM in which the student is given the names of ions to combine and is required to give the correct formula of the compound. The accuracy of the response is checked and suitable comments given the student for each response.

Testing and Evaluation involves the program giving a series of problems or questions and checking for accuracy. The student is informed immediately of errors and can be directed to suitable areas of study for improvement. The scores can be stored and evaluated by an instructor or the program can be such that if a score is not good enough the student can re-take another similar test on the same material. It should be noted that with minicomputers there is the capability of teacher-student communication via the keyboard at appropriate times. One such time might be following a test or if a student is having interactive difficulties with a simulation or drill.

Individualized Problems and Questions are problems specifically designed for the needs of an individual. The student's needs and interest would have to be known and the program carefully written or edited for him. Original work like this takes time and effort but such programs can be categorized and edited for either later use with the same student or altered for use with other students. Such revision and editing is simpler and requires much less time than the original and the programs can be used from year to year with proper care and revision. Programs and programming has been mentioned many times with the implication that special training will be required for teachers and students. As with driving a car some training is necessary but the amount will vary with the needs of the individual and the system involved.

Student use of a microcomputer involves using a cassette tape recorder in conjunction with the TV tube and an electric typewriter. In that regard it should be noted that typing is not required. The hunt and peck system is perfectly acceptable to the computer—it's in no hurry!

What special training do students and their teachers require to access and use a computer? Student use of a microcomputer involves using a cassette tape recorder in conjunction with the TV tube and an electric typewriter. In that regard it should be noted that typing is not required. The hunt and peck system is perfectly acceptable to the computer—it's in no hurry! In order to use the larger computer (i.e. timesharing) the student would have to learn the phone accessing system. Typically, this involves dialing the computer system's phone number; waiting for the computers answering signal; typing HELLO-NUMBER, PASSWORD and waiting for the computer response. At first, accessing the computer can be awkward, but even small children learn it and enjoy being *in charge.*

The teacher *will* need some background in computer language. The easiest and most useful language for science teachers is BASIC. The writer learned the rudiment of BASIC in an 8 lecture course and less is probably required if programming can be farmed out to specialists who would do that work for a number of teachers under their direction. If such training for teachers is not possible, much of the personalization and individualization will necessarily be lost. It has also been my experience that teachers are more satisfied with their programs if they can revise and update them as desired.

The computer has special attributes, which can not be matched by other means. One such attribute is that of patience. There is nothing more patient than a computer terminal waiting for a student response.

The computer has special attributes, which can not be matched by other means. One such attribute is that of patience. There is nothing more patient than a computer terminal waiting for a student response. It will just sit there humming until some response is made, and will repeat a question or answer or response or experience as long as any student could ever wish.

Another virtue the computer has is that of similar variety. The computer can generate almost an infinite number of examples for student practice. These problems would or could all be similar in style but differing in one small value, thus offering practice without exact repetition. Any of us would tire of this after 8 to 10 such examples but the computer will gladly serve up 50 of them if the student requests.

CAI with voice response for tutorial instruction and practice give vocal feedback to blind students.

An interesting project has been developed in North Carolina. CAI with voice response for tutorial instruction and practice gives vocal feedback to blind students. Using appropriate tones the students are taught by the system the computer keyboard and their questions and answers are vocalized by a voice synthesizer. The project[3] uses a microcomputer whose major components are "off-the-shelf," that is, available on the general market and not developed specifically for that project. While the subject matter is data processing, I believe that Project VOCAB is a groundbreaker which should develop into a monumental beginning for teaching blind students.

An interesting and one of the most promising statements concerning CAI was made before House subcommittee. It was that federally funded CAI projects in Los Nietros, California had reversed a 16 year decline in math achievement scores. "Before computers, the district had tried to improve[4] students' academic achievement by hiring more teachers, teachers' aides, and bringing in enough volunteers to have one adult for every seven students in the district. But after three years, student achievement had actually dropped slightly." 24 microcomputers with CAI reversed the trend and improved the scores by 2 years' growth on achievement scores and there was also improvement in other than math scores which were due to CAI.

A final example relating to the special advantages and to the flexibility of computer-assisted-instruction is from the American Annals for the Deaf[5] and it concerns the teaching of poetry. To enhance the non-hearing persons' feeling for poetry "textured-words" are used to relate poetry visually. The texture animated presentation of language is used to alter the space-time presentation in which the concepts of the poem are delivered; similar to the way in which a poem is orally rendered. The words and phrases appear in special order and arrangement in a special rhythm to give the student a better feeling for the content of the poem than would the words by themselves offer.

It has been the purpose of this paper to indicate to the reader some of the ways that computer systems could be used in the teaching of physically handicapped students. It is my belief that by such use the quality of such education would be higher than can be obtained in other ways and the cost could be substantially lower. It is not *the answer* to our problems in teaching. It is an answer to some very tough questions concerning the education of our future citizens who need special help.

Bibliography

1. Hewlett-Packard Educational Programs-Contributed Program

2. *Huntington Computer Project,* General Services Dept. 836 North Street, Tewksbury, MA 01876

3. *The Wang Laboratories Programmer,* March 1977, p. 18-21, "Project Vocab"

4. *Education of the Handicapped,* Nov. 9, 1977, p. 7, "Computer-Assisted-Instruction Helps Low-Achievers, Congress Told"

5. *American Annals for the Deaf,* Feb. 1976, p. 38-43 "Computer-Animated and Textured Presentation of Language for the Deaf," by Arthur Layzer

6. *Computers and the Learning Process in Higher Education* J.F. Rockart and M.S.S. Morton, McGraw Hill Book Co. 1975

7. *The Computer and Education,* Education Technology Publishing Co., 1973 Englewood Cliffs, NJ

7

Science and the Visually Handicapped

7

Science and the Visually Handicapped

Introduction

Much of our science teaching is highly visually oriented: textbooks, diagrams, demonstrations, models, films, and manipulative activities that necessitate the use of vision. Science is collecting information about our physical world through the use of all our senses. This chapter presents ideas on what it means to teach science to visually handicapped students, or those students who are unable to function effectively in a visually oriented science program.

The chapter begins with a discussion about the value of planning multi-sensory activities for visually handicapped students. It is evident that there are implications for using multi-sensory science activities also with non-handicapped students. Several common myths or misconceptions about visually handicapped persons and the way they function in a classroom are clarified. One author illustrates how models and real things can be used in science. A summary of pertinent information on the design and use of tactile aids is also given.

The Tactile Modality in Adapting and Developing Science Materials

Frank L. Franks
American Printing House for the Blind, Louisville, Kentucky

Tactile and manipulative aids as media for illustrating and teaching numerous concrete principles and concepts have been part of the educational scene for centuries, particularly in science instruction. Because of the greater emphasis and broader applicability of instructional media in general and special education through visual and auditory channels, integration of tactile apparatus is a learning resource in media systems has been severely impeded until recently. The major efforts in adaptation and development of educational aids focusing on the tactual modality have been for blind students whose primary educational channel for learning concrete operations is through tactual perception. However, utilization of this modality for the broad range of students who can profit from tactile in-put is now receiving greater attention in educational programs as the result of a variety of influences. These include: changes in the functional ability of the handicapped population, the refinement of research designs in studies in tactual perception, the increasing application of technology in education, the greater emphasis on multi-media approaches, increasing operational costs in education, mainstreaming of handicapped students, and the change in direction in elementary science teaching over the past 10 years. The tactual modality has significant implications for the majority of handicapped students when used in conjunction with other modalities to develop functional abilities in the cognitive, the affective, and the psychomotor domains.

A small body of tactual research related to adaptation and development of educational materials in science for the handicapped appears in the literature on the blind. A review of this literature will be included in the following pages. Only research which used blind subjects will be cited.

■

Aids produced by the sighted often appreared to be tactile counterparts of materials that were originally designed for visual presentation, while efforts by the blind were more tactually oriented.

Early Aids Adaptation and Development

Numerous records of educational aids developed by blind and sighted individuals are found in the literature. Aids produced by the sighted often appeared to be tactile counterparts of materials that were originally designed for visual presentation, while efforts by the blind were more tactually oriented. In reviewing the evolution of tangible aids, Ritter (1950) found that the development of such aids for the blind has been a concern of educators for many centuries. He noted that numerous inventions have appeared but that recorded descriptions of these early aids for the blind were scanty at best and frequently did not mention the discoveries which preceded their development.

Zahl (1950) stated that eminent blind people of the past must have worked out solutions to many of the problems which still confront the blind today, but that little provision was made to preserve or pass on these solutions. He noted that no concerted effort by blind *and* sighted to devise aids was made until the advent of schools for the blind in 1785. Formal attempts in providing models for research related to adaptation, development, and evaluation of tangible aids in science for the visually handicapped have occurred only within the past 50 years.

Formal research investigations in the use of tactile aids with blind students as subjects do not appear in the literature until the 1930's. In three studies to determine the usefulness of animal models in teaching blind students, conclusions by Merry (1930) supported the need for beginning nature study with young blind students, the superiority of three-dimensional models over two-dimensional representations of three-dimensional objects, and the necessity of much care in selecting animal specimens for use with blind students. However, these studies used very small numbers of subjects and did not present data nor report statistical tests to support conclusions drawn.

In a series of studies which did present supportive data analysis, the Merrys investigated tactual recognition of embossed pictures by blind students. Two-dimensional designs and three-dimensional objects (embossed in paper in two-dimensions) were presented to subjects who were asked to name the designs and objects. Results of the studies (Merry, 1930, 1932; Merry & Merry, 1933) indicated that bi-dimensional simplified outlines of common objects may be of some value but that tri-dimensional designs representing perspective on two planes have no real meaning for blind students.

Changing Attitudes of Science Educators

A sampling from the *Proceedings of the American Association of Instructors of the Blind* (AAIB) was made from the 1920's, the 1930's, and the 1940's to determine if the attitudes of educators during these years might have affected the adaptation and development of tangible aids for teaching science to blind students. The majority of blind students were educated in residential schools during the years prior to 1959. The AAIB was comprised of educators in these schools and reflected their attitudes regarding the use of tangible aids in science in the *Proceedings.*

■

The majority of blind students were educated in residential schools during the years prior to 1959.

In summary, science instruction beyond general and introductory courses progressed slowly until the advent of World War II when greater emphasis was placed on science instruction. In the 1920's and 1930's, the attitudes of teachers of blind students reflected were: teacher performance of ex-

187

periments; question of teaching science at all to blind students; acceptance of science as a legitimate course for the blind; the use of odds and ends to teach science; to have students perform simple, but limited, experiments with assistance. The 1940's brought broader recognition of the value of models, embossed materials, and other tactile aids for the blind. During this period, however, there were no substantial increases in research or systematic advances in educational aids adaptation or development. Mandola (1967), in a sampling of the literature of this period, found no attempt to support the value of adapted or developed aids by empirical evidence or by quoting research studies that might lend support. Validity was based on impressions and opinions of educators who adapted and developed materials and of authors who wrote about them.

Guidelines from Research for Adapting and Developing Educational Aids

■

The amount and quality of research on tangible apparatus and the number of aids produced have been meager.

The amount and quality of research on tangible apparatus and the number of aids produced have been meager. The 1950's contributed little research on educational materials specifically related to tangible aids (Ashcroft, 1959; Lowenfeld, 1963; Nolan, 1963, 1969). However, systematic research into basic problems in perception of tactile media began to increase in the 1950's. A number of research studies in which empirical data were actually collected on blind subjects were examined to determine if results and conclusions from the studies might yield information which could be utilized in establishing guidelines for adapting and developing specifications for educational aids in science. (Most of the studies are related to map reading.) While none of the studies investigated problems specifically related to materials development in science, a number of clues underlying the tactile design of educational aids and/or displays on these aids were revealed and a sampling follows.

Complexity of design. An immediate consideration in the design of any tactile aid is complexity of tactile displays encountered by students using the aid. Tactile displays for blind students differ from visual displays for sighted students in that the blind student requires tactual interaction with the aid or apparatus. The studies investigated revealed that:

1. Contrast is the most important principle for raised-line diagrams and simplicity is possibly the second most important (Schiff, 1966).

2. On simple tests of tactual perception, both good and poor braille readers were found to perform equally well. Good braille readers were able to handle highly complex tactually perceptive material better than poor readers (Weiner, 1963).

3. Tactile arrays should be kept as simple as possible and the number of symbols kept to a minimum (Schiff, Kaufer & Mosak, 1966; Wiedel, 1969; Wiedel & Groves, 1969).

188

Discriminability of symbols. Three types of patterns—point, linear, and areal symbols—are needed for graphic communication.

1. Discrete sets of point, linear, and areal symbols have been identified by Nolan and Morris (1971) in studies of tactual symbols for blind children. This reference also contains a review of related literature.
2. Discrete sets of symbols were identified by Gill and James (1973) and Wiedel and Groves (1969). Some point symbols which are often confused were identified by Jansson (1972). This reference also contains a review of literature on point symbols.
3. Blind students may have difficulty in recognizing differences in sizes of embossed dots as they appear in combination with each other or with certain other symbols (Nolan & Morris, 1963).
4. Textured sandpaper surface patterns of varying degrees of roughness are effective means of indicating different areas when size differences are moderate or large (Nolan & Morris, 1965; Schiff & Isikow, 1966).
5. There are probably large differences in degrees of noiseness among any set of discriminable textures (Lederman & Taylor, 1972).
6. A difference of two millimeters between histograms is barely adequate and actually too small for efficient interpretation (Schiff & Isikow, 1966).
7. Distance between dots (.090 inch), distance between braille cells in a line (.160 inch), and distance between lines of braille print (.220 inch)—distances occurring in Standard English Braille—are easily read (Meyers, Ethington, & Ashcroft, 1958; Weinstein, 1968).
8. Overall legibility of areal symbols remains good until the symbols are reduced to three-quarter inch squares (Nolan & Morris, 1963) to one-half inch squares (Heath, 1958).

Tactile edges and lines. Raised lines (Nolan, 1971) and distinctive tactile edges (Schiff, 1966) are excellent ways of providing discriminable differences in area coding.

Stimulus redundancy. Redundancy involves encoding a message so that it contains more syllables or stimuli than the minimum necessary to transmit the information contained in the message. As diagram difficulty increases, additional redundancy appears to play a role in reducing errors. The best method of presentation in diagrams when "noise" level is high is the textured *and* raised format (Schiff & Isikow, 1966).

Scanning. Scanning or tactual inspection of tactile displays requires physical interaction for adequate comprehension of the symbols employed in the displays.

1. Although braille is often considered as a difficult, cumbersome, and illogical system, children learn to read braille and to read it quite well (Ashcroft, 1960).
2. The braille character is the perceptual unit in braille word recognition (Nolan & Kederis, 1969).
3. The blind cannot "scan" a map but must form an image of it piece-by-piece (Sherman, 1965).
4. Size should be such that the user can cover a significant portion of a map with one hand and orient with the other hand (Wiedel & Groves, 1969).
5. Berla' (Nolan, 1976) describes the preliminary scanning operation of blind students as a two-handed rapid, global, and unsystematic inspection with the finger tips. He found that training students to scan is effective before strong habits have been established.

Science Materials Studies Utilizing Guidelines from Research

Adaptation and development of educational materials for blind students have been hampered not only by the lack of systematic research procedures but also by failure to secure and employ research findings which are available. This section reviews educational materials development projects in science for blind students which have relied on guidelines drawn from studies in tactual perception. Some of the studies were conducted as geography and map study projects but are useful in teaching earth science concepts.

Adaptation and development of educational materials for blind students have been hampered not only by the lack of systematic research procedures but also by failure to secure and employ research findings which are available.

In the following studies, models adapted/developed emphasize simplicity, but offer redundant features where complexity is unavoidable. Texture, size, shape, and relief were used to maximize legibility. Chromatic coding was employed to maximize color and luminance contrasts for low vision students.

Franks, F. Measurement in science for blind students. *Teaching Exceptional Children,* 1970, *3,* 2-11.

> Instruments necessary to teach measurement operations and basic properties of matter were identified. As a result a thermometer, a ruler in inches and centimeters, and a spring and a pan balance were adapted for tactual inspection by blind students. In the study 86% of the measurements and simple experiments were successfully performed by 51 junior high and 19 elementary school students using the aids.

Franks, F., & Baird, R. M. Geographical concepts and the visually handicapped. *Exceptional Children,* 1971, *38,* 321-324.

The results of this study indicate that the series of three-dimensional raised surface landforms reported provide highly discriminable illustrations of 40 basic geographical terms for use by visually handicapped students. The system of tactile and chromatic coding which was developed provides easily discriminable cues and surface areas, even for some braille readers with extremely limited residual vision. Overall percentage of correct identification of the features illustrated on the landforms was 83.5%.

Franks, F., & Murr, M. J. *Biological models for blind students.* Unpublished report, American Printing House for the Blind, 1973.

Nineteen plastic models (schematics) which illustrate representative species of the major phyla and component structures of flowering plants were developed. The biological features depicted on the models were found to be highly discriminable in a test of legibility (95% overall correct responses) with 42 legally blind students (grades 7-12).

Franks, F. Introduction to map study: Teaching locational and directional referents to young blind students. Doctoral dissertation, George Peabody College for Teachers, 1974.

Three maps which sequentially introduced areal, linear, and point symbols were developed. The format facilitated the interrelation of fundamental map reading concepts with the classroom, with the school environment, and with natural and cultural features within the community. Eighty legally blind students (grades K-6) were used in the study. Computations using the Kuder-Richardson Formula 20 to determine consistency of the pretest and the posttest revealed a reliability of .95 for the pretest and a reliability of .95 for the posttest. Significant gains in learning beyond the .01 level of significance were reported for 26 of the 30 concepts taught in the program. The small increase in learning on the four remaining items is attributed to prior knowledge.

Franks, F., & Huff, R. Educational materials development in primary science: The pull-apart cell. *Education of the Visually Handicapped,* 1976, *1,* 16-20.

The study evaluated the ability of 61 young visually handicapped students (grades 2-4) to discriminate textures and to utilize them in locating and identifying the layers on a pull-apart cell model (schematic). The study also evaluated the ability of students to manipulate the pull-apart features of the cell model. As a group the students scored well above the chance level on discrimination and identification-location tasks. Ninety-seven percent of the subjects were able to identify all discriminations correctly. The results confirm that young visually handicapped students in this study were able to perform the discrimination and identification-location tasks necessary for learning the parts of a simple plant and animal cell with pull-apart features.

Franks, F., & Huff, R. Educational materials development in primary science: Insect identification kit. *Education of the Visually Handicapped*, 1976, *2*, 57-62.

The primary purpose of this study was to determine if 71 young visually handicapped students (grades 2-4) could learn to identify the basic body parts of an insect on a three-dimensional model (schematic) using a set of training materials. The combined performance scores for braille and large print students using the insect models ranged from 91% to 100%. The complete kit contains a set of five models.

Franks, F., & Huff, R. Educational materials development in primary science: Dial thermometer instructional unit. *Education of the Visually Handicapped*, 1976, *4*, 120-124.

The results of this study indicate that the majority of 61 subjects (grades 2-4) were able to locate and recognize the point, areal, and linear symbols tested on the dial thermometer schematic, to locate specific lines, and to locate specified point and linear symbols using a pointer as set by the examiner. One hundred percent of the subjects located and recognized four distinctive features on the dial thermometer schematic: any raised line, the raised circle, the raised rough surface, and the pointer.

Franks, F., & Huff, R. Educational materials development in primary science: Linear measurement for young blind students. *Education of the Visually Handicapped*, 1977, *1*, 23-28.

A tactile ruler instructional unit was evaluated using 37 legally blind students (grades 2-4). Tasks in counting inch and centimeter lines exceeded the criterion of 80% correct responses.

Franks, F., & Butterfield, L. H. Educational materials development in primary science: Simple machines. *Education of the Visually Handicapped*, 1977, *2*, 51-55.

> The study evaluated the ability of 27 legally blind students from the elementary grades (ages 7-13) to identify and manipulate the parts of the lever, the inclined plane, the wheel and axle, and the pulley. Performance scores exceeded 90% correct responses on each machine.

Implications and needs

There is a need for more research in basic problems in perception of tactile media across disability areas and for more systematic development and testing of instructional aids in which empirical data is collected.

A systematic procedure (Franks, 1975) for identifying, classifying, adapting/developing, evaluating, and producing educational aids in science has been developed at the American Printing House for the Blind. This construct also provides the educational researcher an operational strategy for integrating classroom observation, teacher expertise, relevant research, and educational technology in the development of educational aids. The construct can be expanded and refined to meet specific needs of educational researchers across disability areas.

■

Technical and educational innovations which have applicability to the systematic research and development of educational materials should be examined. These innovations include: the media movement . . . systems analysis . . . programmed instruction . . . and prescriptive teaching . . .

Technical and educational innovations which have applicability to the systematic research and development of educational materials should be examined. These innovations include: the media movement, which has expanded the use of instructional media in educational programs; systems analysis, which has made a significant contribution in determining and setting behavioral objectives and providing for functional feed back systems; programmed instruction, which has indicated guidelines for sequentially teaching these operations using educational media; and prescriptive teaching, which has provided a model for studying the interaction between students and teachers through diagnosis, intervention, and evaluation procedures.

Examination of critical contingencies in the development of tactile educational aids provides a foundation for further research. The feasibility of incorporating these materials into instructional programs not only for blind students, but for all students who exhibit learning deficits that are amenable to such remediation should be explored. Employing guidelines for tactual legibility across disability areas—where feasible—could contribute to maximum availability to blind students, at a minimum cost, many aids which would not require further adaptation and development. The utilization of the tactual modality for the broad range of students who can profit from such experience is a more appropriate approach to materials adaptation and development than the generation of educational aids for specific disability groups within the total school population.

References

Ashcroft, S. C. The blind and partially seeing. *Review of Educational Research,* 1959, *29,* 519-528.

Ashcroft, S. C. *Identification of braille reading errors.* Unpublished doctoral dissertation, University of Illinois, 1960.

Franks, F. L. Educational materials development in primary science: An introductory science laboratory for young blind students. *Education of the Visually Handicapped,* 1975, *7,* 97-101.

Gill, J. M., & James, G. A. A study on the discriminability of tactual point symbols, *American Foundation for the Blind, Research Bulletin,* 1973, No. 26, 19-34.

Heath, W. R. *Maps and graphics for the blind: Some aspects of the discriminability of textural surfaces for use in areal differentiation.* Unpublished doctoral dissertation, University of Washington, 1958.

Jansson, G. Symbols for tactile maps. In B. Linqvist and N. Trowald (Eds.), *European Conference of Educational Research for the Visually Handicapped.* Project: PUSS: VIII. Report No. 31, 1972.

Lederman, S. J., & Taylor, M. M. Fingertip force, surface geometry, and the perception of roughness by active touch. *Perception & Psychophysics,* 1972, *12,* 401-408.

Lowenfeld, B. The visually handicapped. *Review of Educational Research* 1963, *33,* 38-47.

Mandola, J. *Graphic aids for the blind.* Unpublished master's thesis, Michigan State University, 1967.

Merry, F. K. A study of the merits of animal models used in teaching blind children. *Teachers Forum,* 1930, *2,* 12.

Merry, F. K. A further investigation to determine the value of embossed pictures for blind children. *Teachers Forum,* 1932, *4,* 96-99.

Merry, R., & Merry, F. Tactual recognition of embossed pictures by blind children. *Journal of Applied Psychology,* 1933, *17,* 148-163.

Meyers, E., Ethington, D., & Ashcroft, S. Readability of braille as a function of three spacing variables. *Journal of Applied Psychology,* 1958, *42,* 163-165.

Nolan, C. Y. The visually impaired. *Behavioral Research on Exceptional Children,* 1963, 115-154.

Nolan, C. Y. Research in education of the blind. In M. H. Goldberg (Ed.), *Blindness research.* University Park, Pa.: Pennsylvania State University Press, 1969.

Nolan, C. Y. (Ed.), *Facilitating the Education of the Visually Handicapped through Research in Communications.* Final Report of the Department of Health, Education and Welfare. Project No. OEG-0-73-0642, 1976.

Nolan, C. Y. Relative legibility of raised and incised tactual figures. *Education of the Visually Handicapped,* 1971, *3,* 33-36.

Nolan, C. Y., & Kederis, C. J. Perceptual factors in braille word recognition. *American Foundation for the Blind, Research Series,* 1969, No. 20.

Nolan, C. Y. & Morris, J. E. *Tactual symbols for the blind: Final report* (OVR-RD-587). Louisville, Ky.: American Printing House for the Blind, 1963.

Nolan, C. Y., & Morris, J. E. Development and validation of the Roughness Discrimination Test. *International Journal for the Education of the Blind,* 1965, *15,* 1-16.

Nolan, C. Y. & Morris, J. E. *Improvement of tactual symbols for blind children: Final report* (Project No. 5-0421; Grand No. OEG-32-37-0000-1012). Louisville, Ky.: American Printing House for the Blind, 1971. (ERIC Document Reproduction Service No. ED 070 228).

Ritter, C. Devices to aid the blind. In P. A. Zahl (Ed.), *Blindness.* Princeton, N. J.: University Press, 1950.

Schiff, W. *Raised line drawing research project: Final report.* New York: Recording for the Blind, 1966.

Schiff, W., & Isikow, H. Stimulus redundancy in the tactile perception of histograms. *International Journal for the Education of the Blind,* 1966, *196,* 1-11.

Schiff, W., Kaufer, L., & Mosak, S. Informative tactile stimuli in the perception of direction. *Perceptual & Motor Skills,* 1966, *23* (3, Pt. 2), 1315-1335.

Sherman, J. C. Needs and resources in maps for the blind. *New Outlook for the Blind,* 1965, *59,* 130-134.

Weiner, L. The performance of good and poor braille readers. *International Journal for the Education of the Blind,* 1963, *12,* 72-77.

Weinstein, S. Intensive and extensive aspects of tactile sensitivity as a function of body part, sex, and laterality. In D. R. Kenshalo (Ed.), *The skin senses.* Springfield, Ill.: Charles C. Thomas, 1968.

Wiedel, J. W. Tactual maps for the visually handicapped: Some developmental problems. *New Outlook for the Blind,* 1969, *63,* 80-88.

Wiedel, J. W., & Groves, P. A. *Tactual mapping: Design, reproduction, reading and interpretation: Final report* (SRS Grant No. RD-2557-S). College Park, Md.: University of Maryland (Department of Geography), 1969.

Zahl, P. *Blindness: Modern approaches to the unseen environment.* Princeton, N. J.: Princeton University Press, 1950.

Fostering Observation in a Science Program for the Young Blind Student

Herbert D. Thier
Lawrence Hall of Science, University of California, Berkeley, California

Observation and Evidence

In all of science, direct or indirect observation is basic to the collection of all evidence. This evidence is the raw material from which we construct the process called science; that is, we utilize the evidence from our observations to formulate problems and design approaches for solving those problems. Whether the approach is successful or not, the conclusions that are drawn are based on the evidence collected and the interpretation of that evidence. This emphasis on observation and evidence is what distinguishes scientific from nonscientific thinking. The most elegant theory or explanation in science has its roots in a body of evidence, and is only valuable if it *continues* to provide a consistent explanation of new observations and evidence.

Conant[1] describes this emphasis on observation as follows:

> As a first approximation, we may say that science emerges from the other progressive activities of man to the extent that new concepts arise from experiments and *observations* and the new concepts in turn lead to further experiments and *observations*. The texture of modern science is the result of the interweaving of fruitful concepts. The test of a new idea is therefore not only its success in correlating the then-known facts, but much more its success or failure in stimulating further experimentation or *observation* which in turn is fruitful.

This emphasis on observation and the collection of evidence as a basis for the development of conceptual theories is the very nature of scientific thinking. Therefore, if we want young people to grow up "scientifically literate," we must provide them with opportunities to engage in the scientific process. This must begin with an emphasis on observation and the collection of evidence which in turn become the basis of all further activity in science.

Observation and the Sighted Student in Science

The worldwide development of science education for young children can be characterized by an ever-increasing emphasis on providing the learner with opportunities to make observations, collect evidence, and use that experience as the basis for engaging in scientific thinking. The emphasis is the same in programs ranging from the Science Education Program for Africa (SEPA)[2] that is designed to meet the needs of rural children in developing African nations to the new Rand McNally SCIIS Program.[3] (a revision of Science Curriculum Improvement Study materials) designed for a wide variety of schools in the United States. Whether the program depends, for any of a variety of reasons, on the local environment or provides sophisticated kits of materials, the purpose is to provide boys and girls with increased opportunities to make observations, collect evidence, and utilize this information to engage in scientific thinking. Twenty years ago in the United States, for example, supplementary equipment and materials kits were nearly nonexistent, but today they are integral parts of virtually every commercial science program.

The increased emphasis on observation and the collection of evidence is apparent; it is an important outcome of the recent curriculum reform movement in elementary science education.

The increased emphasis on observation and the collection of evidence is apparent; it is an important outcome of the recent curriculum reform movement in elementary science education. Further, it is not at all surprising that these observations and experiences are overwhelmingly dependent on visual inputs, since our society is extremely visually-oriented. Most of our descriptions and explanations of all aspects of life are visual in nature. This is due to the value and usefulness of visual inputs, and also the ease with which they can be collected by the nondisabled individual.

Our general tendency, especially in education, is to ignore other forms of sensory input. In developing science materials for young children, we have been somewhat more effective in utilizing other sensory input, but this effort is still very limited. In any given program, the number of activities that are primarily dependent on sensory inputs other than the visual is quite small. And many of those that do emphasize sound, touch, or other senses still rely on the child's visual memory for the conclusion of the activity. If, for example, children are asked to sort objects by the sounds they make when shaken in a closed box and to guess what those objects are, their guesses rely heavily on prior visual experience with similar objects. In addition, most activities emphasizing other senses are found in the very early grades, whereas little emphasis on other senses is apparent in the upper grades.

Relying primarily on sight tends to limit the richness of experience of sighted children and may hamper the development of their overall powers of observation.

Relying primarily on sight tends to limit the richness of experience of sighted children and may hamper the development of their overall powers of observation. However, because society is predominantly oriented toward visual sensory input, people may not consider a lack of other sensory experience to be critical to their perceptual ability. In effect, many people lack the sensitivity to realize the role that other senses play in providing rich sensory input.

On the other hand, emphasizing additional sensory input in conjunction with vision provides children with multi-sensory experiences in their environment. This leads to a greater understanding and enjoyment of those experiences. For example, shifting a child's focus from the traditional question "What does it look like?" to "What can you tell me about it?" involves the child in a multi-sensory response. In many cases, only simple probing is required to convert a solely visual experience into a multi-sensory one.

In the case of the interaction between vinegar and baking soda, for example, bubbles are produced. This visual stimulus makes this a popular "experiment" in elementary school programs, but rarely is the child asked to describe the *sound* produced by the interaction or whether the final product *smells* the same as the original ingredients. Both of these latter questions would foster a multi-sensory approach that could lead to increased understanding of the science involved. Furthermore, taking a multi-sensory approach leads to increased language use and development as the child tries to more fully describe what is happening.

Typical Approaches to Observation for the Young Blind Student

For the young blind or seriously visually impaired child, the need for a multi-sensory approach seems obvious. If quality visual input is not available to the child, then one would expect that ways would be developed for these children to observe and gather evidence about their environment using the other senses. Actually, this is not the typical approach to the development of materials and experiences for the visually impaired. Rather, the emphasis is placed on ways to give the visually impaired child "visual experiences." For example, raised-line drawings are often used to convey pictorial information on the assumption that the lines themselves constitute the entire picture. In reality, however, a great deal of the sighted child's information comes from the visual perspective and relationships found in the drawing or picture that cannot be transmitted to the blind or visually impaired by raised-line drawings alone. Even less effective is the assignment of different textures to represent colors so that visually impaired children can "see" colors. This type of approach does little to foster color awareness (which probably cannot be developed for the totally blind child), but does have some value as a means of teaching code, i.e., smooth=red, rough=blue, etc.

Another procedure used in activities involving visually impaired children is to have a sighted partner describe what is happening during the course of an experiment. This frequently leads to the sighted partner dominating the activity, while the visually impaired child fades into the background as a spectator. This not only deprives the visually impaired child of the experience, but also burdens the child to explain what took place as if he or she were actually "part of the activity." Needless to say, the efficacy of all sensory inputs, including the nonvisual, is highly dependent on the degree to which the visually impaired child is involved in carrying out the activity. It's hard for children to *smell* the change that takes place when baking soda is mixed with vinegar unless they mix the two themselves. Naturally, there are times when the help of a sighted colleague can be very useful, but the partnership should always be designed to complement and enhance the visually impaired child's sensory experience, and not to diminish it.

Finally, the most widespread approach to science for the visually impaired has been to exclude the seriously visually impaired altogether from activities and experiences that were considered too dangerous for them. Again, there are certain things that the seriously visually impaired should avoid for reasons of safety, but these are few and far between if we consider appropriate experiences for elementary school children. In fact, many activities that are unsafe for the blind child are most likely unsafe for the sighted child as well. The "protectionist" approach has prevented many blind and partially-sighted children from having the opportunity to interact with their environment in a meaningful way. Public Law 94-142 and related legislation will make much of this illegal. But more important than legislation *per se* is changing the attitudes of professionals in the field towards the education of blind and visually impaired children. An overly protective environment is an especially sterile one for the young blind children, who can't see what others are doing and don't even become envious or rebel.

The "protectionist" approach has prevented many blind and partially-sighted children from having the opportunity to interact with their environment in a meaningful way.

What Is Possible For the Young Blind Student

For the past nine years, the staff of the Lawrence Hall of Science has been developing and testing a variety of approaches for providing young blind students with realistic opportunities to make observations, gather evidence, and particpate effectively in the "doing of science." This work began with the adaptation on a trial basis of most of the materials in the Science Curriculum Improvement Study (SCIS) Program[4] and, currently, work is proceeding on the development of a wide variety of science activities and experiences to be used by teachers of the visually impaired and other professionals in order to provide meaningful science experiences for these children. The activities are organized into modules and the choice of modules and activities is based on areas of need and interest identified by teachers of the visually impaired.

In this work, the emphasis has been on what the child can do, *utilizing all of his or her available senses, instead of on how that child might be made to behave like a sighted person.*

In this work, the emphasis has been on what the child *can do*, utilizing all of his or her available senses, instead of how that child might be made to behave like a sighted person. Rather than starting with pictures and trying to develop realistic raised-line representations, the work at the Lawrence Hall of Science has emphasized multi-sensory inputs using real objects and experiences in the form of either adapted or newly developed materials. In this way, the conceptual goal for the visually impaired can remain the same while the approach to reaching it can be re-designed to highlight their strengths and capabilities rather than their disabilities. This is not to say, however, that visual input is ignored; since 75% or more of all legally blind individuals have partial sight, the use of this sense is certainly encouraged.

A major aspect of our work to date has been an attempt to design, develop, and test a variety of devices to foster the blind child's ability to make observations and collect evidence independently. Such simple innovations as developing effective ways of removing equal amounts of powdered materials from a supply container, or equal amounts of water from a pitcher have already provided the blind child with all the equipment necessary to carry out a variety of important and interesting experiments that lead to an understanding of the concepts of *solution, saturation, concentration,* etc. Each of these measurement skills has a direct application to everyday life in a variety of situations.

At times, it is necessary to take an entirely new approach in order to enable the blind child to gather evidence independently. For example, a light sensor was developed in order to give children concrete experience with differing intensities of light. It operates on a photoelectric cell that converts light energy to electrical energy that is, in turn, converted into sound. The brighter the light read by the light sensor, the higher pitched the tone it gives off. Using this device, blind children can perform many valuable everyday activities, such as picking out clothing that is lighter in color and thus safer for the blind person to wear at night. In addition, it can be used in a variety of experiments involving observation of the effect of lenses and mirrors. A sensor can even detect changes in the colors of liquids; it will detect the change of bromothymol blue to yellow after vinegar is added.

Another important consideration in the development or adaptation of activities for the blind child is the development of rugged, reliable pieces of equipment that are neither visually nor tactilely confusing to use. For example, after experimenting with a number of designs, a highly useful multi-purpose sorting and work tray has been developed for the Science Activities for the Visually Impaired (SAVI) Project.[5] In other areas, however, the goal has not been as easy to accomplish. Over the past eight years, we have tried a variety of approaches for developing a satisfactory, yet inexpensive, thermometer that could be easily used by young blind children. Thus far, all of our prototypes have drawbacks and work is continuing on an entirely new approach to the problem. Eventually we will find an answer that will not only meet the needs of the blind and visually impaired, but sighted children as well; whenever we have developed or adapted an effective activity for blind children, it has proved equally effective with sighted children of the same age. It has been our experience that a well-designed science activity for the blind is also an excellent science activity for all children. Sighted children may use it somewhat differently (many legally blind persons may use it as a sighted person would), but it is important to note that a multi-sensory approach to making observations and gathering evidence is highly effective for all children.

Bibliographical References

[1] Conant, James B., *On Understanding Science,* (New Haven: Yale University Press, 1947), p. 24.

[2] Yoloye, E.A., "The African Primary Science Programme," *The Journal of Science Teachers Association of Nigeria,* 9 (1).

[3] Thier, Karplus, Knott, Lawson, Montgomery, et al., *Rand McNally Science Curriculum Improvement Study (SCIIS) Program,* Chicago: Rand McNally & Co., 1978).

[4] Thier, H. et al., *Adapting Science Materials for the Blind (ASMB)*. Based on the SCIS Program, Lawrence Hall of Science, University of California, Berkeley, California.

[5] *Science Activities for the Visually Impaired (SAVI) Project*, (Berkeley: Lawrence Hall of Science, University of California). Funded under a grant from Bureau of Education for the Handicapped, U.S. Office Of Education.

Common Sense and Sensitivity in Teaching the Blind

Elva R. Gough
Special Education, George Peabody College for Teachers in Nashville, Tennessee

All too often the first inkling a science teacher has that a visually impaired[1] student is a member of his or her class comes when they meet face to face. If you are that teacher, you may experience shock, frustration, anger, or any number of uncomfortable emotions. How can you cope with yet another "problem," you may wonder? How can you provide for that student's safety? How much extra time will you have to spend? What should the student be allowed to do, and what not?

Your negative feelings will gradually disappear as you become familiar with the student and his or her capabilities. In the meantime there are several things you should begin doing immediately. First and most important, the student must be thoroughly oriented to your classroom, to the laboratory, and to all the equipment your students normally use. This is essential if he or she is to move about these areas and work independently—and make no mistake about it, the handicapped covet their independence.

■

Your negative feelings will gradually disappear as you become familiar with the student and his or her capabilities. In the meantime there are several things you should begin doing immediately.

The next step is to contact the special education department to find out what supporting services they can provide. I suggest, too, that you contact the American Printing House for the Blind[2] (ask for their science catalog), The American Foundation for the Blind,[3] and your local association for the blind.

Also, ask the totally blind student to make braille labels for you to put on equipment and materials. The student can also make up a set of brailled grades for you to apply to papers, quizzes, and tests (these labels obviate the need for the student to ask others what his/her grades are).

Helping Students "to see"

If you have a visually impaired student in your class, your verbal descriptions should include mention of properties that the visually impaired student can sense; descriptions of size should be made in terms of things the student has experienced (very small objects can often be compared to the size of a braille dot). Sighted students should also be encouraged to add these new sensory experiences to their repertoire of knowledge and skills—such new sensory "alertness" will not only enrich their visual experiences, but will help them retain what they have learned.

---

[1] *A visually impaired student is any student who needs special aids and/or instruction to read ordinary print, was well as the student who must read braille. [5] This includes both totally blind students and partially sighted students.*

[2] *The American Printing House for the Blind (P.O. Box 6085, Louisville KY 40206) has developed a light sensor that permits totally blind students to perceive color changes, plus a variety of other scientific instruments. They have also developed some excellent tactile biology models. These models are painted in vivid colors so that they are useful for both the totally blind and partially sighted students. The models are inexpensive and require little storage space.*

[3] *American Foundation for the Blind, 15 W. 16th St., New York, NY 10011.*

The easiest error for a teacher to make is to assume that the visually impaired student "sees" the same things with his fingers as one sees with one's eyes.

The easiest error for a teacher to make is to assume that the visually impaired student "sees" the same things with his fingers as one sees with one's eyes. (Remember the parable of the blind men and the elephant?) There have been instances in which blind students have made clay models representing what they "see." from the verbal descriptions given them. More often than not these clay models do not resemble the object described. One of the reasons for this lies in the difficulty of formulating a really complete description. Perhaps the best way to gain some sensitivity to the problem is simply to close your eyes and explore and describe the environment available to you through your other senses.

Visually impaired students usually possess excellent vocabularies and are frequently articulate. Thus, it is easy for the inexperienced teacher to be lulled into thinking that these students understand the information about which they are able to speak so fluently.

Visually impaired students usually possess excellent vocabularies and are frequently articulate. Thus, it is easy for the inexperienced teacher to be lulled into thinking that these students understand the information about which they are able to speak so fluently.

But very often, if the student is presented with the object represented by his words, he fails to recognize it. For example, he may know that a "chick" is a young chicken, but if you hand one to him, he may not recognize it because he has never "seen" one before. Most sighted students will recognize the chick even if they have never seen a real one because they have seen pictures. But braille textbooks are filled only with words—there are no illustrations.

Visually impaired students are like sighted students in their needs for acceptance, success, independence, and friendship. But they differ in their abilities to meet some of these needs. [4, 8] For example, independence is hard won when you can't see the partially open door that invites a head-on collision. In addition, understanding changing relationships with members of the opposite sex is a problem. Then, too, that ultimate adolescent status symbol—the driver's license—is impossible to attain. Frustrations are plentiful for adolescents in general, but the visually impaired student has even more to contend with.

Labs and the Visually Impaired

In the science classroom, especially, one of the needless frustrations the visually impaired student has had to accept in the past is being barred from laboratory activities. [12] But these students are no more reckless than sighted students, nor do they have more accidents. [9]

Research indicates that the average high school student has *not* attained Piaget's formal level of mental processes [7] and still requires concrete, hands-on activities to develop the numerous concepts in science. The blind student is no exception and may, in fact, have even greater need for experience with a wide variety of physical objects. [3, 10] The sighted adolescent, after all, acquires many concepts through visual experiences—from textbook illustrations, teacher demonstrations, film media, and simply by looking at the world. The visually impaired adolescent is denied all of this to varying degrees, depending on the severity of the handicap. Thus, the visually impaired student develops primarily through physical interaction with objects—that is, by touching, smelling, tasting, and hearing. [1,3]

One of the oft-repeated fallacies is that a blind student's sensitive braille fingers must be protected. Obviously, one would not want to injure the child's fingers or nerve endings, but isn't this true, too, for sighted students? Blind students commonly use needles, pins, scissors, knives, and other sharp objects in the ordinary activities of their home life. How then can we rightfully deny students the opportunity to participate in dissections, examine cacti, or inject hormones into chicks in the laboratory? (Public Law 94-142 may, in fact, prohibit such discrimination.)

Fire, too, is a dangerous fact of life for blind students, as for all students. But, again, blind students can be taught to safely light and use a Bunsen burner.

Many experimental procedures require no adaptations at all for the visually impaired; others need only minor changes. The basic rule for adaptation is to find the properties that can be collected, massed, touched, smelled, heard (or any combination) and to be sensitive to any danger that these properties might represent to the blind.

The visually impaired student is usually a professional at adapting things so that he or she can benefit from them. This in itself is a headstart. By combining your experience with that of the blind student, you will learn and grow.

The visually impaired student is usually a professional at adapting things so that he or she can benefit from them. This in itself is a headstart. By combining your experience with that of the blind student, you will both learn and grow.

These, then, are some things to consider in working with the visually impaired. The joys and satisfactons derived from watching the visually impaired student acquire skills and knowledge side by side with sighted students are tremendous rewards for a little extra effort.

References

1. Bateman, B. "Psychological Evaluation of Blind Children." In *Problems and Issues in the Education of Exceptional Children,* Reginal L. Jones, editor, Houghton Mifflin Co., New York, N.Y. 1971. Pp. 141-148.

2. Brown, Dean R. "Instruction of Physically Handicapped Youth in Science." In *What Research Says to the Science Teacher, Volume 2,* Mary Budd Rowe, editor. National Science Teachers Association, Washington, D.C., 1979.

3. Cutsforth, T. D. *The Blind in School and Society.* D. Appleton and Company, N.Y., N.Y. 1933.

4. Davis, C. J. "Adustment of the Blind Adolescent." In *Blindness Research: The Expanding Frontiers,* Maxwell H. Goldberg and John R. Swinton, editors. The Pennsylvania State University Press, University Park, Penn. 1969.

5. Harley, R. K., Jr. "Children with Visual Disabilities." In *Exceptional Children in the Schools, Special Education in Transition,* Lloyd M. Dunn, editor. Holt, Rinehart and Winston, Inc., New York, N.Y. 1973.

6. Hayes, S. P. *Contributions to a Psychology of Blindess.* American Foundation for the Blind, Inc., New York, N.Y. 1941.

7. Lawson, A. E. and J. W. Renner. "Relationships of Science Subject Matter and Developmental Levels of Learners." *Journal of Research in Science Teaching* 12:347-358; October 1975.

8. Lowenfeld, B. "The Blind Adolescent in a Seeing World." *Exceptional Children,* March 1959. Pp. 310-315.

9. Lowenfeld, B. *Our Blind Children, Growing and Learning with Them.* Charles C. Thomas, Publisher, Springfield, Ill. 1964.

10. Lowenfeld, B. "Psychological Aspects of Blindness." *Outlook for the Blind* 41:31-36; February 1947.

11. Molloy, L. "The Handicapped Child in the Everyday Classroom." *Phi Delta Kappan* 56: 337-340; January 1975.

12. Nolan C. Y. "Research in Education of the Blind." *Blindness Research: the Expanding Frontiers,* Maxwell H. Goldberg and John R. Swinton, editors. The Pennsylvania University Press, University Park, Penn. 1969.

THE SCIENCE TEACHER 45:9, 34-35, December 1978

Teaching the Mammalian Heart to the Visually Handicapped

Pearl Francoeur
Science Education Department, McGill University, Montreal, Canada
Bilhah Eilam
Hebrew University, Jerusalem, Israel

Language cannot always be relied upon to convey concepts to the sighted child. [1] Children may verbalize without understanding, just as they may understand without being able to verbalize. Jean Piaget has demonstrated that the ability of sighted children to deal with broad concepts depends on their direct sensory experience. [2] The visually handicapped (those who are totally blind or who have only partial vision) must rely on tactile and other sensory experiences for perceptual and conceptual development. Otherwise they will suffer from what the Connecticut Institute for the Blind calls the "verbal unreality of the blind," a situation created because sighted people naturally use their own mental imagery to describe things to the blind—objects, concepts, and ideas for which the blind have no personal experience. [3]

The activity described in this article—teaching the mammalian heart to high school students—is particularly adapted to today's integrated classroom (one containing sighted and visually handicapped). [4-6] It demonstrates that basic biological concepts may readily be taught using standard materials plus raised diagrams, which can be prepared at any school with the help of sighted students and a thermoform machine. The exercise makes use of programmed instruction, a method proven extremely effective with the visually impaired. [7] In fact, programmed instruction has been found well suited to many parts of the science curriculum.

■

Otherwise they will suffer from what the Connecticut Institute for the Blind calls the "verbal unreality of the blind," a situation created because sighted people naturally use their own mental imagery to describe things to the blind—objects, concepts, and ideas for which the blind have no personal experience.

Developing Concepts

Two main concepts are to be gained in this exercise: the relationship between heart structure and function, and the relationship between heart structure and body temperature. Both relate to the larger concept of evolution from cold- to warm-blooded.

The exercise is presented to the students by means of the unit plan approach, which groups all activities into an easy-to-follow, logically structured format. For the visually impaired, this approach leaves nothing to accident. Each step and its relation to the next is clearly accentuated, allowing for complete concept formation. [8]

We try to base as many of our laboratory activities as possible on the discovery method, in which the student deals with data and then must call upon his own creative thinking to discover new relationships and principles, sometimes with teacher guidance. [9]

Models vs. the Real Thing

An instructional question confronts us in this exercise: Should an iconic model or the real organ be used? [10] A model, being larger than the real thing, reduces complexity and permits greater clarity. There is the risk, though, that the student will overgeneralize from the model to the real thing, resulting in erroneous conclusions. Fulker has recommended that biological models be made according to a uniform scale to enable blind students to gauge comparative sizes. [11] Of course, the models on the market today make this kind of comparison impossible. For the blind student, the model conveys three-dimensionality and shape, but it lacks other equally important characteristics such as true size, texture, warmth, movement. Therefore, it is terribly important that misconceptions not be bred through premature use of models.

■

We prefer to begin an anatomical study using real organs. Only after the objectives are understood do we use the model for complementary study.

We prefer to begin an anatomical study using real organs. Only after the objectives are understood do we use the model for complementary study. To exhibit relative size relationships of the heart to other organs, and the location of the heart within the organism, we use a model of the human body which can be broken down into different organ components.

Musts for Models

When designing or adapting models for use with visually impaired students in integrated classes, two points must be considered. First, colored areas on models for the sighted must be changed to textured areas. This can be done by mixing glue with all kinds of materials—fine sand, coarse sand, bits of paper, small peas or beans. Or, contrasting textures may be produced by spreading glue on certain areas while others are left as is. Second, iconic models are interconnected by means of nails which enter little holes; these are very difficult for the blind to assemble. Magnetic models avoid this problem. If they are unavailable, existing models may be economically altered by attaching small pieces of magnets to all the separate parts in place of nails and holes.

■

First, a well-known animal is preferable in order that the blind student can relate what he or she learns about the heart of this animal to what is already known.

Three considerations must be taken into account when selecting the type of heart to study. First, a well-known animal is preferable in order that the blind student can relate what he or she learns about the heart of this animal to what is already known. Second, the heart of a large animal makes studying detailed structures easier for blind students. A very large cow's heart, however, may prove difficult to handle. Third, a fresh heart, not one preserved in formalin, is preferred, because it approximates true muscle texture and warmth. (When preserved, the organ tends to shrink and harden.)

Teaching Strategy

Lab sessions which incorporate work and discussion—as opposed to a completely self-paced and potentially isolating instructional approach—have proven especially valuable for the handicapped. A taped unit may be prepared, with students working through the exercise in groups of two. Or, the teacher may prefer to hand out written study guides, and supplement with oral questions and discussion.

In this exercise, we use three raised diagrams. The first is a simple, labeled, exterior view of the heart, such as may be found in most elementary biology texts. It shows the major vessels entering the heart, plus two slits (one in each ventricle) where we have made incisions so that students can insert probes. The second is just a rough schema, indicating the two major circulatory pathways (one to the lungs, the other to the body tissues), and the location of the tricuspid, bicuspid, and semilunar valves. The third is a cross sectional view that directs the students where to place their probes.

It is our intention that all students completing the unit be able to achieve the following behavioral objectives, based on Bloom's taxonomy of cognitive educational objectives.[12]

Knowledge—

1. Identify and name the heart structures.
2. State the major generalizations that relate structure to function.

Comprehension—

1. Recognize a correlation between heart size and animal size.
2. Explain how heart structure and body temperature are related.

Application—

1. Describe how the above knowledge and comprehension of heart structure and function can be useful in:
    a. Study of other animal systems and classes of organisms.
    b. Identification of concrete cases of heart disease.

Analysis—

1. Identify the heart structures which pump blood out of the heart, and those which return blood to the heart.

2. Explain the basis for your identification.

Synthesis—

1. Draw a cross-section of the mammalian heart and indicate the pathways of blood circulation through it.

2. Schematically illustrate the complete pathways of blood circulation from the heart to the body tissues, to the lungs, and the return circulations. Use arrows to indicate the directions of blood flow.

Evaluation—

1. Predict the function of each of the heart valves observed.

2. Describe how an artery and a vein are different and how they are similar in structure, function, texture, thickness. Comment on other differences and similarities.

Laboratory Procedure

The heart of a sheep or a pig is given to each student group. In all specimens, two cuts have been made through the walls of the ventricles—one through the left and the other through the right.

In addition, each student group is given the following materials.:

- Four probes of two different textures: two wooden and two glass; or, for the sighted, two of one color and two of another.

- Braille rulers [13]; or, for the sighted, regular rulers or micrometers. [14]

- A balance for the blind [14-16]; or, for the sighted, a regular balance.

- A small laboratory guide in braille alphabet or in conventional characters containing the entire unit's activities, instructions, and questions.

- Board and modeling clay; or wax-filled dissection pan or aluminum foil to draw on.

Students are told only that the mammalian heart is a four-chambered organ, with right and left atria and ventricles, and that a cut has been made through the wall of each ventricle. They are told that the left ventricle wall is thicker than the right ventricle wall. We also tell the students the name of the animal being studied and its approximate body weight (kilograms) and size (meters). They are then asked to follow written directions:

Gently pass your fingers over the entire outer surface of the heart, then answer the following questions: (a) What type of tissue is this organ built of, hard or soft? (b) Are all parts of the heart of a uniform degree of hardness? (c) If your answer is no, which parts are softer, the upper or the lower? (d) Knowing that the heart functions as a pump, what type of tissue would you suppose the heart is predominantly built of? (e) Since the lower parts are harder, predict whether their muscle content differs from that of the upper parts. (f) Can you feel any external feature which suggests a separation of the heart into right and left? Does this depression separate the ventricles equally? (g) Can you feel any raised lines (tube-like) on the heart wall or in the area of the depression? What do you think these might be? Because these blood vessels supply blood to the heart itself, they are named coronary vessels.

Weigh the heart; measure its length; measure it at its greatest width. Compare these to the animal's approximate weight.

Put your fingers into the left ventricle. Measure the thickness of the left ventricle wall. Do the same for the right ventricle wall: (a) Which wall is thicker? (b) Based on your knowledge of how the heart functions, try to explain your results. (c) Is there more muscle tissue in the left ventricular wall than in the right one?

Push the wooden stick into the left ventricle and the glass stick into the right ventricle. Push both sticks straight up. If you get caught in something, push the tissue aside so you can pass through. Now you have passed into the upper parts of the heart, called atria: (a) Feel the external size of the two atria. Are they different? (b) Can you feel your sticks by pressing on the atrial walls? By pressing on the ventricle walls?

Make a small cut in the wall of each atrium, then measure the wall thickness: (a) Is there any difference in the thickness of the two atrial walls? (b) Since atrial walls are less thick than ventricle walls, are they less muscular? What can you predict about the function of the atria? (c) How might the blood therefore pass from the atria to the ventricles?

Search with your fingers for the structures which interfered with your pushing the sticks through from the ventricles into the atria: (a) Describe the structural materials these are built of. (b) How many are there in each ventricle? (c) Do you find any similarity between their structure and that of a parachute? (d) From this structural similarity, and the fact that they prevented your sticks from readily passing from ventricles to atria, how would you explain their function? (e) What do we call a structure which can open or shut to allow fluid to flow in a given direction?

Push through the other sticks which you have (again, the wooden to the left, and the glass to the right). Try to find another passage out of the ventricles. (a) Did you encounter any obstacle? (b) What did your stick enter? Blood vessels which carry blood away from the heart are called? Those which carry blood to the heart are called? (c) Do you think the blood vessles connected to the ventricles are arteries or veins? (d) On what fact do you base your conclusion?

Measure the wall thickness of the arteries and also their cross-sectional diameters on both sides of the heart: (a) Compare these arteries. Which is bigger and more muscular? Do you know its name? (b) Explain the above fact, basing your explanation on what you already know about how the heart functions.

Now find the veins entering the heart: (a) Push the first two sticks you used for finding the atrioventricular node further up, and look for other entrances into the atria. Did you find any? (b) What are they opening into? These vessles are the veins entering the atria. (c) Measure the wall thickness, the diameter of the veins entering the left and those entering the right atria, and compare your measurements. Are there any differences? What are they? (d) Can you explain your findings? The main vein entering the right atrium is the superior vena cava, and those entering the left atrium are called the pulmonary veins.

Compare all your data for measurements of veins with those for measurements of arteries in the left and right sides of the heart: (a) Which type of vessels (arteries or veins) are bigger in tube diameter, have thicker walls, and are more muscular? What might be the differences in function?

Now, summarize your data on the double blood cycle by making a schematic drawing showing the double blood cycle. Check it against the drawing provided.

Arteries are muscular; they contract to help push the blood forward: (a) What problem might arise to interfere with a one-directional arterial blood flow? (b) How might this problem be solved? (c) Now it is clear why you encountered no hindrance to pushing your stick through in the direction from ventricles to arteries. (d) How can you prove the existence of valves? Push a stick through in the opposite direction, from arteries into ventricles. Did you encounter anything? (d) Describe the valves you encountered. Are they similar in structure to those between ventricles and atria?

Try to find an opening between the left and right parts of the heart. Did you find one? (a) The left side of the heart receives its blood supply from the ______ where it has been oxygenated. This blood therefore is high in ______ gas. This oxygenated blood passes into the ______ ______ and is pumped to the organs and tissues of the ______. (b) The right side of the heart receives blood from the organs and tissues of the body. Thus, this blood is oxygen-deficient and high in carbon dioxide gas. This blood passes through the ______ ______ which pumps it to the ______ where it picks up fresh ______ and gives up carbon dioxide. This oxygenated blood then returns to the ______ ______. It is obvious that blood arriving at the cells and tissues of the body brings ______ and removes ______ ______ gas. Also, blood arriving at the lungs brings carbon dioxide to be exchanged for fresh oxygen. (c) In your opinion what would happen if there were a passageway between the left and right sides of the heart? What type of gas would the cells of the body get? (d) Since the oxygen provided to cells is used for energy production, receiving less oxygen would result in? This would produce a lower metabolic rate (body activity), and a lower body temperature.

Summary

We have learned that the mammalian heart structure provides the possibility for the existence of two entirely separate circulatory systems. One system is responsible for gas exchange with the environment (via the lungs); the other for gas exchange with the tissues. The efficiency of energy production that results from these separate systems makes possible homeothermy: warm-bloodedness and a constant body temperature.

The different components of the heart structure are each fully adapted for their specific functions and enable a one-directional blood flow: From veins through the atria and ventricles to the arteries—with valves to guard that flow.

Evaluation of Student Performance

Evaluation includes all the possible questions based on the stated behavioral objectives. It is preferable to give each student a different kind of heart from the one originally studied. Have the student: (1) Identify and name all the heart structures; (2) Determine whether this heart provides a double blood circulation; (3) Predict the approximate weight and body size of the animal.

With the increasing trend toward integrated classrooms, it is hoped that a greater number of science teachers will educate themselves to the problems of instructing the visually handicapped, and will recognize the handicapped student's special need for concrete experience.

References

1. Athey, J. and O. Duane Rubadeau, Editors. *Educational Implications of Piaget's Theory.* Ginn Blaisdell. 1970. P. xvi.

2. Piaget, Jean. "Development and Learning." *Journal of Research in Science Teaching* 2(3): 176-185; 1964.

3. The Connecticut Institute for the Blind. "Basic Concepts of Blind Children." *The New Outlook for the Blind* 29:341; December 1965.

4. Shumway, H. Smith. "Wyoming Visually Handicapped Children Attend Public School." *The New Outlook for the Blind* 58:142; May 1964.

5. Misbach, Dorothy L. and Joan Sweeney. *Edcation of the Visually Handicapped in California Public Schools.* California State Department of Education, Division of Special Education, Sacramento, Calif. 1970.

6. Tonkovic, Franjo. "An Approach to the Problem of Integrated Education of Blind Children." *The International Journal for the Education of the Blind* XVI:115; May 1967.

7. Morin, A. Edward. "Programmed Instruction, Today's Challenge in Educating Visually Handicapped." *Education of the Visually Handicapped* 2:8-11; March 1970.

8. Lowenfeld, Berthold. *Our Blind Children—Growing and Learning With Them,* Second Edition, Charles C. Thomas, Publisher, Springfield, Ill. 1964. Pp. 173, 175.

9. Suchman, J. Richard. "Creative Thinking and Conceptual Growth." *Gifted Child Quarterly* 6: 95; Autumn 1962.

10. Anderson, D. R., *et. al. Developing Children's Thinking Through Science.* Prentice-Hall, Inc., Englewood Cliffs, N.J. 1970. Pp. 59-61.

11. Fulker, H. Wilber. "Illustrating Braille Texts." *The International Journal for the Education of the Blind* XIII; October 1963. Pp. 28-29.

12. Bloom, Benjamin S., Editor. *Taxonomy of Educational Objectives: Handbook 1—Cognitive Domain.* David McKay, Inc., New York. 1956.

13. Franks, L. Frank. "Measurement in Science for Blind Students." *Teaching Exceptional Children;* Fall 1970.

14. Wexler, A. *Experimental Science for the Blind, An Instruction Manual.* Pergamon Press, Inc. 1961. Pp. 28-29.

15. Hiemenz, C. Paul and Elizabeth Pfeiffer. "A General Chemistry Experiment for the Blind." *Journal of Chemical Education* 49:263; April 1972.

16. Tombaugh, E. Dorothy. *Biology for the Blind.* Printed by Euclid Public Schools. Euclid, Ohio. 1973. Pp. 1-4.

THE SCIENCE TEACHER 42:10, 8-11 December 1975.

8

Extending the Science Program Beyond the School

[illegible]

8

Extending the Science Program Beyond the School

Introduction

The inclusion of handicapped students in science related activities should not be limited only to the classroom. The handicapped can benefit from out-of school activities just as much as the non-handicapped. Nature centers, science museums, zoos, and field studies should be accessible to physically handicapped students. This means there should not be architectural barriers, nor other barriers that will prevent the students from being fully involved in the activities. For example, deaf students should not have to rely solely on their vision to gain knowledge on a field trip to a coastal region. An interpreter may be required to allow these students to also verbally participate in the learning activities.

A variety of ways that science education can be extended beyond the school for the handicapped is presented in the chapter. An elementary school faculty designed and developed a nature center in a woodland setting that was accessible to handicapped students. A curriculum guide was prepared to maximize the potential use of the nature center for these children. A program that involved muliple types of handicapped high school students in marine science field studies is described. The program, directed by university personnel, was held during the summer months. The focus of one article is on the potential role of science museums in helping educate the handicapped. Science museums can modify their programs so they are accessible; serve as a resource center for specialized instructional aids and materials; and help teachers learn how to use unique techniques and materials appropriate for teaching handicapped learners. The chapter also provides a brief overview of how an environmental recreation program can assist in the education of handicapped youngsters.

Science Education in a Woodland Setting: A Program for the Handicapped

Carl Fenn
Donald K. Hamilton
Department of Education,
Western Illinois University,
Macomb, Illinois

Handicapped children are unique individuals with no two being exactly the same. But like all of us, each one has a peculiar combination of abilities and disabilities which are constantly in the process of changing as the individual grows and learns. Unfortunately many have disabilities which inhibit their opportunities to explore the great outdoors. Children confined to wheelchairs ordinarily cannot take a simple walk in the woods to enjoy its sights or to explore and discover that world which is so distinctly different from the confinements of a house. Visually impaired children do not receive the visual stimulation to explore a flower garden or the world of animal life to be found at the top of the trees or crawling through the ground in the woods or a pasture. The thrill of discovering this world creates an excitement for learning which cannot be duplicated in a classroom.

■

each one has a peculiar combination of abilities and disabilities which are constantly in the process of changing as the individual grows and learns.

How could a school provide these kinds of experiences for handicapped chidren, thus meeting the mandate of providing an "appropriate education" for all handicapped children as required by Public Law 94-142? The need for a woodland setting in which an educational program could emerge to accomplish the following objectives was evident:

1. To stimulate language and motor development.
2. To encourage the use of their senses in teaching, listening and observing.
3. To advance their basic science concepts pertaining to plant and animal life.
4. To learn to preserve our natural resources through thoughtful care and management.
5. To gain an appreciation and enjoyment of the out-door environment.
6. To develop hobbies which will provide constructive use of their leisure time.

■

It required policing to control for motor bikes and refuse disposal. Recognizing that this ravine had the potential to be developed into an outdoor learning laboratory for handicapped children,

Behind the Eugene Field Elementary School in Rock Island, Illinois is a ravine. It required policing to control for motor bikes and refuse disposal. Recognizing that this ravine had the potential to be developed into an outdoor learning laboratory for handicapped children, work was initiated during the Summer of 1975 with supportive funding from a Title III ESEA grant. Concrete walkways from the school to the woods were constructed with raised beds of plants and flowers along side to enable children confined to wheelchairs and those who are partially sighted to learn about nature by being close to it.

More than 400 volunteer hours were given to the project by such diverse groups as children who attended the school, professional builders, the lady next door, and the boy who often used the woods for trails to ride his mini-bike. The imagination of the community was captured into developing a resource to be used in educating handicapped children.

■

The imagination of the community was captured into developing a resource to be used in educating handicapped children.

The special children at Eugene Field Elementary School required a program that reflected an amalgamation of the thinking and planning of the science educator, the special educator, the curriculum evaluator, and the classroom teacher. A team representing these various interest areas was assembled to prepare the curriculum materials for the program. The March 1976 issue of *Science and Children* identified a number of ways of involving the handicapped in the outdoor environment.[1]

The approach of the writing team was to prepare activities that utilized the child's senses in developing an awareness of the woodland environment. As the child became aware, sequential activities called for higher level skills of classification, communication, measurement, vocabulary development, predicting, inferring, and experimenting. A curriculum guide was prepared including sample activities which would be used on site, instructions for teachers for scheduling and using the site, and materials that were available at Eugene Field for doing the investigations. The variety of activities included "Awareness Along the Trail," (Lesson in this article) "Listen and Hear," "Studying the Soil," "Animal Signs and Tracks," "Trees in the Ravine," "Leaves," "Getting Bugged," "Temperature, Wind and Humidity," "In the Snow," and "Hobbies From Experiences in the Ravine."

With the completion of the curriculum guide a center was established at Eugene Field. The center housed sets of materials that were required for the activites on site. Copies of the guide were distributed to the schools in the city, and scheduled visitations to the site were arranged through the center staff. These visits were coordinated with the on site usage by the handicapped providing many mainstreaming opportunities. For many of the handicapped children it was their first opportunity to experience a woodland environment. To be lifted out of the wheelchair, and laid on the ground, to feel the dew, to smell a flower, to be stuck by a thorn, to catch a bug, to caress the soft green moss was an experience of lasting and endearing value. Reactions included hesitan-

■

To be lifted out of the wheelchair, and laid on the ground, to feel the dew, to smell a flower, to be stuck by a thorn, to catch a bug, to caress the soft green moss . . .

---

[1] *Lombardi, Thomas P., and Black, Patrick E., "Science Experiences and the Mentally Retarded," Science and Children, Volume 13, Number 6, March 76, p. 20.*

cy; a look of concern, happiness, an exclamation of joy, pleasure; a smile, a laugh, interest; careful examination and questions and more questions; sharing; "look at mine."

Operation of the site was to include visits by regular science classes through-out the district which provided an excellent opportunity for mainstreaming the handicapped with other children. As the teacher scheduled a visit with a regular or handicapped class she was given an evaluation check list which was left at the end of the day. This process of continuous activity evaluation provided a mechanism for modification of the program based on users recommendations.

Sample activity on page 224.

Sample of Activities in a Woodland Setting for the Handicapped

Title

Awareness Along the Trail

Materials

No particular equipment is provided for this activity, but one should examine the trail to make sure that s/he will find some of the suggested items.

Rationale

A walk through the ravine can be more than a "bunch of trees, bushes, weeds," but often it is necessary to point out to children the richness of the environment, and this activity should be done prior to any structured experiences in the ravine.

Objectives

After this activity the child should be able to:

1. Describe the characteristics of a woodland trail.
2. Identify three different smells along the trail.
3. Identify at least five different sounds heard along the trail.
4. Give some of the history of the region.

Procedure

Sensory Awareness Trail

1. Close your eyes and examine the back of this tree by touch alone.
2. What descriptive words would you use to describe the texture?
3. Stop for a quiet moment by the brook, listen.
4. What sounds do you hear?
5. Dip your hand in the water. Does it feel warmer or colder than the air?
6. Can you estimate the temperature of the water?

7. Close your eyes and listen again. Can you hear different birds?
8. How many kinds of bird calls do you hear?
9. Examine the leaves on this tree.
10. Can you sketch the veins? How would you describe them?
11. Is the leaf compound or simple?
12. Is the leaf margin smooth or scratched?
13. Look around you. Is this virgin timber? Has it always been timber? Are all the trees the same age? How many different kinds of trees do you see from where you are standing?
14. Look at a dead log. How old was the tree? Can you tell the wet years from the dry years? Was the log a part of the trunk (stem) of a tree or was it a branch? If it was a branch which side was up? Which years would be good rabbit years? Crush one of the leaves. Smell it. How would you describe the odor? Smell a handfull of humus. What does it smell like?

Observation Trail

- Describe this flower. What does it look like to you? How many petals What color are they? How are the leaves arranged on the stem? Have the flowers gone to seed? Describe the seed. Examine the bird-feather, note its color and size. Describe the location where you found it. Does this location where you found it give you any hint as to the type of bird? Can you guess from what bird this came from?

Problem Solving Trail

1. Can you figure out what animal has been here?
2. What clues can you find? (Evidence of footprint, fur or feathers left behind).
3. Can moss on a tree be relied on as an indicator of direction?
4. Does moss always grow on the north side?
5. Check this out on at least 10 different trees to see if the theory holds true.
6. If you were lost in the woods and had to live off the land in this area for several days, which plant would you select as a source of food?

Skills Involved

Auditory discrimination, auditory memory, visual discrimination, visual memory, tactile discrimination, language development, motor development.

Age Level

3 to 12

Marine Science Field Experiences with Handicapped Pre-College Students

E. C. Keller, Jr.
Helen E. Keller
West Virginia University, Morgantown, West Virginia

Several years ago, while conducting pre-college summer programs for outstanding students in the life sciences, it was observed that few handicapped students were among the final selected participants. Selections of these students were based on several attributes: Sequential Testing of Education Progress (STEP) scores, science course grades, Pre-Scholastic Aptitude Test (PSAT) scores, and IQ level along with other aspects (i.e., samples of writings, reasons for wanting to attend the program, their past year's reading list). Little note was given to the fact that there were only one or two handicapped participants over the several years of the West Virginia University pre-college honors programs. During an evaluation of these programs at West Virginia University (Keller, *et al.* 1977) it was confirmed that there were, indeed, extremely few handicapped participants. A survey was conducted in 1975 of the 110 Student Science Training (SST) programs for outstanding pre-college students funded by The National Science Foundation. The objective was to ascertain the proportion of handicapped participants in the various NSF/SST programs. The result of this survey showed that there was a 16 to 20 fold deficiency[1] in handicapped participants as compared to the proportion of handicapped individuals in the general population. The reason for the deficiency was due to the fact that very few handicapped students applied.

■

. . . it was observed that few handicapped students were among the final selected participants.

■

The reason for the deficiency was due to the fact that very few handicapped students applied.

A proposal was submitted to The National Science Foundation requesting support for a special program in the Marine Sciences for outstanding handicapped pre-college students. The program was carried out at the Marine Science Consortium's Wallops Island, VA facility, and contained blind, deaf, and orthopedic disabled students. The program was successfully concluded on July 29, 1977 with 23 handicapped participants. The program started with 24 participants, but one of the severely handicapped orthopedic participants returned home on the third day.

The primary *objectives* of this project were to introduce outstanding handicapped pre-college students to Marine Sciences, to directly interface these handicapped students with college faculty, and to assess the success and failure of various components of this program as a function of the various types of participants.

---

[1] *The difference in these estimates reflects the range of estimates of handicapped individuals in the general population.*

The approach *was to operate the program in a traditional academic manner with lecture, laboratory, and field experience across three major topics: Scientific Communication and Methods, Marine Biology, and Physical Oceanography.*

The *approach* was to operate the program in a traditional academic manner with lecture, laboratory, and field experience across three major topics: Scientific Communication and Methods, Marine Biology, and Physical Oceanography. For the academic portion of the program, the 23 participants were in the field about 45%, in laboratory about 30%, and in lecture about 25% of the time. Each student also had a mini-research project that he completed over-and-above the regular presentations.

Description of the Program

. . . modifications such as brailled materials, tactile models, signers and reverse-interpretors.

The "traditional" program was taught using lectures, visual aids, laboratories, and field experiences, with modifications such as brailled materials, tactile models, signers and reverse-interpretors.

The content of the program was divided into sub-topics under three respective major topics viz., the first major topic (Scientific Communications and Methods) dealt with: descriptions of the general coastal area near Wallops Island, VA; introduction to science and the marine sciences; scientific methods; hypotheses and their testing; design of experiments; types of information; means, standard deviations, and ranges; observational/descriptive exercises; barrier island transect evaluations; and transect sampling and analyses.

Sub-topics for Marine Biology included: zones of the ocean; zones of the bay; methods of collecting, identifying, and preserving marine specimens; sampling the various zones for plants and animals; energy transfer; trophic levels; animal behavior; habitat specification; coastal bird studies; *Donax* clam migration; marine physiology; and estuarine dynamics.

Sub-topics for Physical Oceanography were: general aspects of oceanography; components of the ocean and coastal waters; equipment used in oceanographic studies; introduction to meteorology; a visit to the National Oceanographic and Atmospheric Administration (NOAA) meteorological station; navigation; waves and currents; tides and variation in tidal heights; water quality and its assessment; the evolution of barrier islands; and the formation of beaches.

Along with the academic portion of the program (given above) the participants were exposed to a variety of non-academic experiences including: beach combing, sea shell handicrafts, picnics, canoeing, wildlife films, swimming, tour of National Aeronautic and Space Administration (NASA) facilities, visits to museums and a lighthouse, clamming, fireworks, and hikes.

Three other integral activities were: A seminar on the progress of the mini-research projects, a final formal research seminar, and writing "laboratories" . . .

Three other integral activities were: A seminar on the progress of the mini-research projects, a final formal research seminar, and writing "laboratories" (mainly dealing with how to write a scientific paper).

The mini-research project was performed over the latter portion of the program. The projects were short and were usually completed in several days, but they were completed over the last half of the program. Seminars were based on the topics of the participants' projects. Topics of the completed mini-research projects were:

1. Comparison of Sand Grain Sizes Between the Beaches of Assateague (open ocean) and North Wallops (protected by sandbars).
2. Sand Grain Size and the Occurrence of *Donax* Clams.
3. Preparation (including brailling) of Herbarium Specimens of the Plants from the Dune Areas of North Wallops Island.
4. Respiration Rates of Male and Female Fiddler Crabs at Two Different Temperatures.
5. Substrate Preference of Blue Crabs.
6. The Number of Trees with and without Galls on Small and Large Scarlet Oak Trees on the Marine Science Consortium Campus.
7. The Importance of Vision and Smell in Killifish Feeding.
8. Environmental Preferences of Male Blue Crabs.
9. Temperature Tolerance of Killifish.
10. Food Preference of Blue Crabs.
11. The Occurrence of *Melampus* Snails in Low Marshes.
12. Periodicity of Clam Respiration.
13. Comparison of Salinity and Temperature at Low and High Tide at Four Different Locations.
14. Temperature Tolerance Ranges for Large and Small Mole Crabs.
15. The Effects of Tides on Salinity.
16. Environmental Remote Sensing.
17. The Activity and Respiration Rates of Killifish in Different Types of Water.
18. Root Depth of Sea Rocket Plants in Relation to their Distance from the Ocean.
19. Colored Light Preference of Fiddler Crabs.

20. The Density of Bayberry Bushes in Three Zones on North Wallops Island.

21. Feeding Time Preference of the Blue Crab.

22. Light and Cover Preferences of the Blue Crab.

23. The Effects of Temperature and Relative Humidity on Plant Density.

Problems of the Program

■

The major problems were not concerned with the academic aspects of the program, but dealt with the free-time portion of the program.

Aside from the usual problems of operating a summer program, several unique problems were noted. The major problems were not concerned with the academic aspects of the program, but dealt with the free-time portion of the program. Because of the severity of the handicaps (total blindness, total deafness, or wheel-chair bound) the staff felt that there was an extra degree of concern and attentiveness necessary. For example, the counselors were not all signers and when dealing with the deaf participants this caused difficulties, especially in the field and after-hours activities. Excessive dormitory noise, by the deaf participants, caused problems for the other participants in studying and sleeping. Free-time programming of recreational activities that were utilizable by all participants were difficult to design and/or accomplish.

■

The difficulties in the academic portion of the project centered around the communication difficulties between the deaf and hearing participants and the deaf participants and the non-signing staff.

Another major non-academic problem dealt with the lack of air conditioning for the lecture and laboratory aspects of the program. This is not usually a unique problem, however it is for certain types of handicaps (asthmatic, some orthopedic, etc.). Likewise, sleeping problems in the non-cooled dormitories led to difficulties (noise plus discomfort were more of a problem for certain specific handicapped individuals).

The difficulties in the academic portion of the project centered around the communication difficulties between the deaf and hearing participants and the deaf participants and the non-signing staff. Although there were two excellent interpreters and reverse-signers present (both were science teachers) throughout the program, the dialectic differences in signing, coupled with the generally lower reading level of the profoundly deaf participants altered the articulation levels of the instructors and the comprehension of the textual material of the profoundly deaf students. The pace of the program was slowed somewhat by these communication problems and certain of the other (non-deaf) participants became annoyed. The research projects helped in remedying this problem since the after-lecture, after-laboratory briefings (in a reinforcement session by the interpreters) were only attended by those individuals needing clarification and further explanations. The other participants were free to work on their project during this reinforcement session. The blind taped the lectures and used the tapes as after-class reinforcers. A problem specified by the blind participants concerned the lack of specific braille materials, but from the academic evaluations this deficiency did not significantly hamper academic performance of the totally blind students.

■

A problem specified by the blind participants concerned the lack of specific braille materials, but from the academic evaluations this deficiency did not significantly hamper academic performance of the totally blind students.

Evaluations in the Program

Three participant evaluations were performed: 1)the description/characterization of the participants, 2) personality profiles, and 3) academic performance.

Physical and Achievement Characterization of the Participants

The program included three general groups of handicapped participants: blind, deaf, and orthopedic. While an effort was made to recruit an equal number of each type of handicap (and sex), the recruitment resulted in an unequal distribution for both the type of handicap (and sex). The differences in the sex proportions could have been due to interest levels in Marine Science, with proportionately more males interested in Marine Science. There were fifteen students with hearing disabilities, five students with visual handicaps, and three with orthopedic handicaps. Also, one of the twenty-three students had a dual handicap, being both totally blind and orthopedically handicapped (he was classified above as blind). Of the 33 respondents to the recruiting information there were only two minority students. Both of these students were extended offers to the program but only one minority student, a profoundly deaf Native American, accepted and participated in the program.

■

There were fifteen students with hearing disabilities, five students with visual handicaps, and three with orthopedic handicaps. Also, one of the twenty-three students had a dual handicap, being both totally blind and orthopedically handicapped . . .

The science backgrounds of the students were generally quite similar having, on the average, two previous science courses including biology, general science, physical science, earth science, or chemistry. The average science grade for the participants was slightly better than a "B."

The types of schools and academic backgrounds that were represented were extremely varied and, consequently, the indicators of general academic ability were not as complete as might be desired. Of the nine students for whom IQ scores were available, the mean was 116.6. Other scores were also included with the most common, and useable, being the PSAT scores. Of the six students submitting PSAT scores, the averages were 46.3 for verbal and 46.7 for math.

Personality Evaluation of the Participants

Personality evaluations of the participants were done by the staff. The students were evaluated on the basis of twenty personality attributes. These attributes were then grouped into three macro-categories, all of which were scored above the median (i.e., favorable). The most positive grouping of students contained the attributes: friendly, respectful, pleasant, patient, and cooperative. The second (mid-grouping) consisted of the attributes: courteous, participatory, adaptive, responsible, interested, helpful, persistent, resourceful, and industrious. The most negative grouping of students included the attributes: self-motivated, self-disciplined, considerate, mature, aggressive, and competitive. Although the data were not evaluated in a formal manner, the three macro-groupings given above generally corresponded to the orthopedic, blind, and deaf; respectively.

Academic Performance Evaluations of the Participants

Ten separate tests were used, each evaluated a specific aspect of the program. The tests were presented in both written and oral form. The tests were not signed although some questions were explained by signing. After the individual evaluations, the participants were divided into five categories, according to their type and degree of handicap. The categories are presented in Table 1, along with the overall average performance of the group. The lowest values represent the highest (or best) scores.

Table 1. Student Academic Performance by Type and Degree of Handicap

Handicap (degree of)	Ranking	Number	Average Relative Score[1]
Blind (partially)	highest	2	11.5
Hearing Impaired (partially)	next highest	4	13.0
Blind (total)[2]	third highest	3	13.7
Orthopedic	next to lowest	3	17.3
Deaf (profound)[3]	lowest	11	18.0

(1) The lowest score is best.

(2) The tests were usually brailled and the response brailled.

(3) This group had an enormous difficulty in reading and writing in the test environment (as well as in the program in general).

From Table 1, the two partially blind students had the best average performance. The students with partial hearing were second in performance, followed by the totally blind, the orthopedic, the profoundly deaf; respectively. Although the profoundly deaf participants had the poorest average scores, it is not clear whether the testing procedures were biased (against the profoundly deaf), especially due to the fact that this group had the greatest degree of communication difficulty or that certain prerequisite skills were lacking.

■

Although the profoundly deaf participants had the poorest average scores, it is not clear whether the testing procedures were biased (against the profoundly deaf), especially due to the fact that this group had the greatest degree of communication difficulty or that certain prerequisite skills were lacking.

Evaluations by the Participants

Student Attitudes Towards Marine Science

At the beginning, and again at the end, of the program, a series of eight questions pertaining to Marine Science were asked of the students, in questionnaire form.

The eight questions were concerned with whether Marine Science was: fun, practical, of great value, and did they like Marine Science, did they like field work, should everyone study Marine Science, do they like laboratory work, and could Marine Science be of help to the student. The average score for all questions, for both the pre- and post-evaluation, were above the median (generally favorable). There were three clusters of responses in regard to changes in the attitudes of the participants. The most positive changes observed occurred for three questions as to whether Marine Science was: 1) practical; 2) was fun; or 3) was of great value. A mid-group of three questions of less positive change were concerned with: 1) whether the students liked Marine Science; 2) liked field work; and 3) whether everyone should study Marine Science. The final group consisted of two questions which had no appreciable change, viz: whether Marine Science could be of help to the student and if the students liked laboratory work. Hence, the attitudes of all the questions about Marine Science appeared to be positively changes except for the questions concerning the fact that Marine Science would be of great help.

The most positive changes occurred for three questions as to whether Marine Science was: 1) practical; 2) was fun; or 3) was of great value.

Evaluation of Learning Environments by the Participants

Each academic section was evaluated by the students in the form of an anonymous questionnaire at the end of the topic section. These were divided into four classificaions: enjoyment, difficulty, the amount learned, and clarity. The results of the analysis fell into the three major functional groupings of laboratory, lecture, and field sections.

Using a "fun-boring" classification, the responses indicated that the field experiences were the most fun with the laboratory rating next and the lectures the least fun. In the difficulty evaluation there was no difference between the lecture and field experiences, but at the "easy" end of the scale, the laboratories were scored as being the easiest. The consensus of the participants was that the degree of learning was about equal from all three methods of presentation. The clarity aspect indicated that the field sections were the most clear, the laboratories of intermediate clarity, and lectures the least clear. This parallels the responses of freshmen biology students at West Virginia University.

The consensus of the participants was that the degree of learning was about equal from all three methods of presentation. The clarity aspect indicated that the field sections were the most clear, the laboratories of intermediate clarity, and lectures the least clear . . .

Suggestions by the Participants for Improving the Program

The open-ended portion of the student's evaluation are summarized below. The most general comment concerned a desire to have the handicapped and non-handicapped participants of NSF pre-college programs together as one integrated course. Also, several students wanted to have SCUBA included as part of the program. While a few students felt that they should have more freedom after classroom hours, there were many others who stated that there should be more strict discipline and more strictly enforced quiet hours. This apparent contradiction seems to have come about between the non-hearing (wanting more freedom) and the hearing students (wanting more programmed activities). Other comments dealt with organization and scheduling. Since this program was the first of its kind, there were numerous schedule changes and, hence, an appearance of a lack of organization. It was necessary to alter plans due to oversights concerning the facilitation problems, weather, tides, and the coordination of equipment, vehicles, and vessels with the other MSC programs. The need for effective cooling of the laboratory and dormitory rooms was another change unanimously recommended by all participants.

. . . a few students felt that they should have more freedom after classroom hours, there were many others who stated that there should be more strict discipline and more strictly enforced quiet hours.

A few individuals expressed some difficulty with certain of the academic materials such as the scientific method, energy transfer in ecosystems, and in developing their ideas for the short research investigations. Other participants felt that the academic materials should be covered in more depth and should even be accelerated. These types of conflicting recommendations are, perhaps, the most difficult to deal with because some of the students are slower to grasp materials than others, not only because of communication difficulties, but also due to their variety of backgrounds. Some were "mainstreamed" in regular high schools while others were in schools for their unique handicap; although this seemed to make a difference, this difference was not formally evaluated.

■

Some were "mainstreamed" in regular high schools while others were in schools for their unique handicap; although this seemed to make a difference, this difference was not formally evaluated.

There were a few specific comments that apply to certain of the handicaps. One deaf student felt that the signing during lectures was too fast (hence also the lecturer's presentation). In the opinion of the two signers/reverse interpreters on staff, one student, however, did not appear to have adequate signing skills for his grade level. All three totally blind students felt that more of the equipment should be adapted for blind use. One of the three blind participants felt that the blind should be given more to do on the research vessel.

The only orthopedic student completely confined to a wheelchair stated that it was somewhat difficult to get around even with access ramps to all of the buildings used (as well as to the research vessel), but he felt it to be adequate.

In Summary

The experiences gained in the operation of this program must be viewed from the perspective of a group of traditional teachers/scientists/students (on the staff) who had only marginal interface with the integrated teachings of different types of handicapped students. On top of this, the program was strongly field oriented, thereby confounding the problems of the integration across the types of handicaps.

This situation, along with the expertise of one individual who had previously worked with the blind and the expertise of two individuals who had previously worked with the deaf, set up a two-way multi-faceted educational process, one for training the participants in the Marine Sciences and the other for "training" the instructors in the various aspects of communication and facilitation neccessary to successfully complete an integrated "mainstream" (but without "regular" students) program in field sciences.

The objectives of the program were carried out, not without difficulty, but with a reasonable amount of success. The participants all said they would recommend the program to other students in their schools. Hopefully the major non-academic problems will be solved in the next year, since emphasis on non-verbal communication and testing is currently being planned. Those individuals who said a single field oriented program for all types of handicaps couldn't be done were proven wrong and most importantly that assessment was made by the participants themselves.

■

Extensive peer interaction, especially in the field and laboratory areas, was both surprising and beneficial.

Extensive peer interaction, especially in the field and laboratory areas, was both surprising and beneficial. The interactions of note were between deaf and blind in laboratory (finger spelling) and in guidance in the field experiences (deaf guiding blind). Also, assistance was observed in swimming by use of the buddy system (deaf assisting orthopedic and blind). The partial-hearing were of great assistance to the profoundly deaf in peer instruction since all of the partially-hearing also signed. The partially-sighted were of great benefit to the totally blind in all aspects of the program. Many other examples of peer-interaction in instruction were also noted, but were not on as broad a scale as those presented above.

The changes noted in attitudes for the partcipants are being "followed-up" through an evaluation of behavioral changes being conducted by the participants' high school instructors. These evaluations are not complete as yet, however.

The problems associated with the relatively poor academic performance for specific handicapped groups are very difficult ones to access, with these small numbers, however, it is utmost in the minds of the staff. Certainly, this aspect of another program would be emphasized and considered in using alternative evaluation methods.

In the course of the program evaluation, it was felt that it would be useful to construct a rudimentary life function/facilitation matrix by the major category of the handicap which would assist in future planning activities. In Table 2 is given the initial assessment of needs in a pre-college Marine Science Course, according to type of handicap. These needs are those over and above the usual needs of the non-handicapped student. Many of these requirements would also be necessary for any field oriented program and are not unique to Marine Science programs.

As experience is gained in these integrated handicapped programs the list of special needs will be expanded. The problems will be ameliorated somewhat with peer interaction; recall that one of the bright spots of the program was the peer interactions aspects in which there was peer concern and assistance throughout all phases and aspects of the program.

Literature Cited

E. C. Keller, III, R. D. Allen, B. Allamong, J. Allamong, and E. C. Keller, Jr. 1977. Experience in Pre-College Training in Biology at West Virginia University. Proc. W.Va. Acad. Scie. *47*:229-234.

E. C. Keller, Jr. and Helen E. Keller. 1977. Proportions of Outstanding Pre-College Handicapped in Student Science Programs in 1975. AAAS Abstracts, AAAS Annual Meeting, Denver, Colorado.

Table 2. Examples of Resource and Personnel Needs for Teaching, Living Environment Equalization, and Field Experiences for Various Handicaps in Four Educational/Social Environments. These Needs Are in Addition to Those Common Needs in Training Pre-College Students in Marine Science.

Environmental Situation	TYPE OF HANDICAP Blind	 Deaf
Laboratory	"talking" calculator, tactile models, braille materials, recorders, tactile graphics, assistants for tactile graphics, assistance for neutralization of dangerous situations[1], and help with equipment	signer, reverse-interpreter, captional films, increased use of visuals
Lecture	braille materials, recorders, tactile graphics, assistance for tactile graphics	signer, reverse-interpreter, increased visuals, captioned films and visuals
Field	recorder, assistance in description and tactile aspects	signer, reverse-interpreter
Readings and Visuals	reader, or Optacon, braille materials, large type	captioned visuals, supplement readings with signed briefing sessions
Non-Academic	assistance in meals, assistance in travel, assistance in laundry, assistance in organization of personal and academic items	signer and reverse-interpreter for travel, amplified telephones

---

[1] *For example, keeping the participants away from dangerous fish or animal parts (e.g., shark teeth, crab claws, sea urchin spines, sting ray tails, etc.).*

Environmental Situation	TYPE OF HANDICAP Orthopedic	 Multiple Handicap
Laboratory	help with equipment, special tables (heights & designs), wheelchair assistance	combinations of needs according to handicaps
Lecture	recorder or note taker	combination of needs according to handicaps
Field	wheelchair assistance, tie down in boats & vehicles, special transportation needs	combinations of needs according to handicaps
Readings and Visuals	none for moderately handicapped	combinations of needs according to handicaps
Non-Academic	assistance for meals, assistance in travel, assistance in laundry, assistance in bathing	combinations of needs according to handicaps

The Role of the Science Museum in Science Education of the Handicapped

Dennis Schatz
Holly Overman
Pacific Science Center,
Seattle, Washington

Science museums offer a unique resource in the science education of handicapped students that is often overlooked both by the school educator and by the museum staff. This article is addressed to both of these audiences to encourage the greater use of science museums in the total process of science education for handicapped students.

Science museums are natural locations for resource centers that provide in-service workshops concerning the teaching of science to handicapped students and for depositories for loan of adapted science activities, aids and appliances.

Science museums are natural locations for resource centers that provide in-service workshops concerning the teaching of science to handicapped students and for depositories for loan of adapted science activities, aids and appliances. The often unique collections, equipment, and facilities of museums can also offer science experiences at all levels unavailable in any local school district. The need for these resources has become especially acute with the implementation of PL94-142. This has placed a demand on the regular classroom and special education teacher to become knowledgeable about aids, activities, curriculum and teaching techniques appropriate for children with different handicaps.

There are three primary ways that science museums can serve the needs of handicapped students:

1. Become local resource centers for demonstrating and/or disseminating adapted aids, appliances and curricular materials; recommend resource individuals who are interested in working with handicapped students, or have appropriate science materials for use by handicapped students.

2. Provide in-service workshops for both regular classroom teachers and special education teachers concerning techniques and materials for teaching handicapped students, especially in a mainstream situation.

3. Offer museum programs which are appropriate for handicapped students, and actively encourage participation by them.

The Role of the Science Museum in Science Education of the Handicapped

As a Resource Center

There are a number of sources for adapted equipment, such as the American Foundation for the Blind, the American Printing House for the Blind, and the individual state's clearing houses for materials purchased from the American Printing House. There are several curriculum development projects which focus on materials appropriate for various types of handicapped students (Science Activities for the Visually Impaired, Adapting Science Materials for the Blind, Science and Art for Special Children, Me and My Environment). In addition, a number of individuals have reported personal adaptations and equipment or curriculum (Tombaugh, Kaufman, Baughman and Zollman). Although there are national resource centers which keep lists of adapted materials and information on curriculum (National Center on Educational Media and Material for Handicapped, Columbus, Ohio), there are usually few, if any, local resource centers for teachers where they may find out about the existence of the material and also get information on how to utilize these materials in their programs. Science museums can play the vital link in connecting the existing materials and activities to the teacher in the classroom.

■

Science museums can play the vital link in connecting the existing materials and activities to the teacher in the classroom.

It is costly for each school district to provide the in-service workshops and dissemination of information concerning science materials for the handicapped since there are relatively few handicapped students per district. Science museums already function as a science resource for the community on many aspects of science education, and they often serve a large region of a state, or an entire state. Thus they are an ideal, cost effective location for housing resource centers concerning science education for handicapped students. Depending upon the local and state distribution system for items such as close-circuit video systems for the partially sighted, the science museum may want to have these resources also available, or at least available for use during in-service workshop.

As a resource center for students, parents, and other science educators, the science museum should make available for loan science activities adapted for handicapped students. This should certainly include all commercial curricula materials available and should be augmented as the need arises with other materials, either designed by the science museum staff or located through the national resource center, or the museum's own list of appropriate materials.

A full set of basic aids and appliances should also be available for loan, including such items as brailled thermometers, and microfiche or large print copies of activities for visually impaired students.

The science museum should also supply:

1. a resource file of people of interested in working with special education teachers and students;

2. a bibliography of articles on science education for the handicapped;

3. general consultation services;

4. staff training for other science education centers, such as environmental education centers, other museums, scout leaders, etc.

Item 4 is an important area that is too often neglected. Many handicapped youth spend much time in community and/or recreational programs, including summer camps, and after school programs. The introduction of science activities in these informal learning situations can often be the most rewarding and interesting.

In-service Workshops

Housing of a resource center in the science museum leads logically to the single most important service that science museums can offer, in-service workshops concerning the teaching of science of the handicapped students. Some workshops may be offered through local college and universities for those teachers interested in obtaining credit. Individual districts may wish to contract with the science museums to offer in-service programs for their teachers. These workshops may vary from single afternoon, 3-hour workshops to a more extensive multiple session workshop. Many science museums are already familiar with this type of in-service program in the areas of elementary science and mathematics, or specialty areas such as archeology or astronomy.

If external funding can be found, the science museum may want to arrange a more comprehensive in-service mechanism for the entire area they serve. An effective technique doing this is to arrange a three to five week summer workshop that trains leadership individuals to give similar workshops throughout the local area or state. These individuals would meet daily during the 3 to 5 week period to obtain information on materials available and techniques for using these materials. They would also learn strategies to give similar workshops.

During the following school year, these individuals would offer workshops on the school district level to regular classroom and special education teachers concerning the materials they studied during the past summer. They also continue to act as local resource people throughout the year for the teachers in their workshops. The development of such in-service programs, no matter how extensive, would complement nicely, and make known the resources available through the science museum.

Museum Programming

Many science centers have collected materials and equipment which allow them to offer unique science experiences for the students. The Oregon Museum of Science and Industries has science research programs for highly motivated high school students that allow them to do experiments and use equipment not available in the schools. Many science museums have archeological or biological artifacts, or have expensive equipment, such as an electron microscope or planetarium, that are not available in the schools. Many scientists look back to their involvement in science museum special programs as a key motivator in their career in science. Science museums need to make such programs accessible to handicapped students, and this can be easily accomplished using the aids, appliances and skills developed as part of the science education for the handicapped resource center.

■

Many scientists look back to their involvement in science museum special programs as a key motivator in their career in science.

In addition to making more specialized museum programs available to the handicapped, it is important that the science museum analyze its programs at all levels to encourage greater use by the handicapped. Science museums need to modify old exhibits and develop new exhibits which give multi-sensory inputs. Programs at the elementary school level should especially be made inviting to handicapped students, for it is during that time that the students are exploring and molding their future interests. An elementary level student fascinated by a science program is a good candidate for the special high school class. In many cases it will not only be necessary to adapt and modify the program, but it will be essential to actively encourage participation by handicapped students. At the present time, handicapped students do not consider science museums as natural places for becoming involved. Therefore, an effective advertising of programs available will be necessary to get their participation.

Finally the Science Center becomes a logical place to develop science career information, especially since science museums continually work with scientists in the community in the development of all their programs.

Implications for Science Center Staffing and Funding

Implementation of the programs outlined above not only require the commitment of the science museum staff, but hiring of new staff or a change of assignment in the present staff. It will also require the allocation of funding to cover the cost of the program. If new staff is hired, this would be a very appropriate time to implement an affirmative action program to hire handicapped individuals.

■

this would be a very appropriate time to implement an affirmative action program to hire handicapped individuals.

Funding of the program outlined above is substantial for at least the first 1 to 3 years as materials and equipment are acquired, museum programs are adapted or developed and extensive workshops started. We are presently pursuing funds from the Washington State Superintendent of Public Instruction to implement such a program similar to that above. We recommend science museums pursue similar funding in their state. After the initial few years, we believe that the cost of continuing such a program can be incorporated into many science museum's general budgets, possibly augmented by fee for service arrangements with local school districts and/or state agencies.

An essential component of any program for the handicapped is the continuous input from individuals in the community who are handicapped and/or work with handicapped students. An advisory group including regular classroom and special education teachers, handicapped adults and students, and local scientists can help in giving appropriate directions to the museum's program. Equally important, these individuals can help in informing the community about the program's existence.

Science museums are now in the position to offer a unique service to the education community. Neither museum staff nor school educators should pass up the opportunity.

The Environmental Approach to Recreation Services

Karen Littman
Special Services Division
Diane T. Baron
Special Services Division,
The Maryland-National
Capital Park and Planning
Commission, Riverdale,
Maryland

The child with "special needs" presents a challenge to those charged with his or her education and development. Too often, such a child is treated as the exception and is unfortunately denied basic, yet invaluable life experiences.

Environmental recreation can be a spontaneously joyful pursuit, an extremely relevant process by which a handicapped individual can learn to understand and function easily in his own environment.

Environmental recreation can be a spontaneously joyful pursuit, an extremely relevant process by which a handicapped individual can learn to understand and function easily in his own environment. The "special" child needs to have continuous opportunities to explore and acquire the fundamental life experiences that a "normal" child usually receives inadvertently.

The aim of the environmental recreation program is to initiate and improve upon the levels of personal and social functioning of the individual with emphasis on solving persistent life situations. We work to develop and utilize the child's ability to reason analytically, provide situations where self direction can be initiated and thus encourage expressive and creative behavior.

The Special Services Division at MNCPPC was created in June of 1974 to serve the recreation and park needs of Prime George's County's physically handicapped, mentally retarded, visually impaired, hearing impaired children with emotional problems, and senior citizens. The Division works cooperatively with other county agencies to provide recreation programs for the handicapped. The county borders Washington, D.C., and has a population of approximately 150,000 with some type of disability or special need. Programs are based in community centers or parks; whenever possible, the activities are planned out of doors in a neighborhood play area or near a wooded site.

Some people have acquired a vast scope of leisure skills while others maintain a rather limited perspective of recreational insight. We encourage the children to make free choices of activities in a non-sheltered environment and to provide them with the necessary recreational skills to aid in that process.

Too often, the tendency is to "protect" handicapped children from experiencing basic life situations, and unnecessary barriers are set up.

Too often, the tendency is to "protect" handicapped children from experiencing basic life situations, and unnecessary barriers are set up.

The Environmental Approach provides a non-threatening, non-demanding atmosphere that boosts self-confidence through creative experiences. Subsequently, social interaction with other children in the program follows, providing the opportunity to encourage socially acceptable behavior. Creativity, and inventive, expressive efforts through life experiences are encouraged.

Life experiences generally evolve naturally through play activities for the normal child. For the handicapped child, they come more slowly or they must be taught. Play is important for a child. Play activities demonstrate life skills; however, playing consists of many elements which must be learned.

The Environmental Approach involves children in leading activities, planning leisure time, and group and individual projects. Many life experiences such as sharing, demonstrating, and choosing are developed.

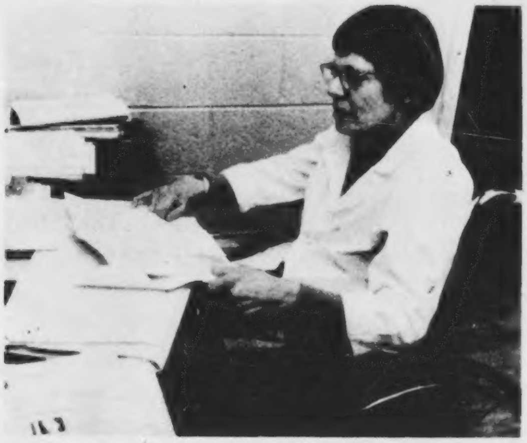
Utilizing life experiences within a program might have children planning a kite-flying day. The children could prepare their own kites, together and alone, choosing their own materials. They could lead their own contests and demonstrate various techniques of flying the kites. The activity would give the children the opportunity to be creative and expressive.

"Special" children are too often considered first in terms of their disability, and as a result programming is centered around this and common recreational experiences are limited. The Environmental Approach can hasten the process by which our "special" children are mainstreamed successfully into society.

Science and Children, *13:7, 22-23, April, 1976.*

9

The Handicapped and Careers in Science and Related Fields



9

The Handicapped and Careers in Science and Related Careers

Introduction

Many people do not consider careers in science and related fields appropriate career choices for auditory, orthopedic or visually handicapped people. It is extremely important that this attitudinal barrier be eliminated. In particular, guidance and vocational counselors, educators, employers, and others who may have an influence on the career choices and opportunities of handicapped persons must be completely open-minded. Handicapped persons should have the same opportunities to pursue scientific or science related careers as the non-handicapped.

This chapter provides an insight into what it means for a handicapped person to seek a career in science. One person, confined to a wheelchair, reflects on her educational experiences from the elementary school through graduate school, and her attempts to have a position that was compatible for both her physical and mental capabilities. A visually impaired person describes barriers she encountered in trying to study science and her decision to go into teaching instead.

The supervising teacher for the woman's student teaching experience tells what it meant to have a visually handicapped student teacher, along with her guide dog, in a kindergarten classroom. Several authors identify the barriers handicapped students encounter in selecting and then trying to attain a position in the fields of science and technology. Overviews of efforts to overcome these barriers and to encourage handicapped students to consider careers in science and technology are given. In one situation qualified high school seniors were located and then provided experiences to motivate them to consider pursuing a scientific career. The efforts of another project were directed toward the development of career guidance materials for more than 200 careers in science and related fields. These materials were designed so handicapped students can use them.

Science Education and Careers: Personal Views from Wheelchair Level

Barbara Jane Mendius
Clark College, Vancouver, Washington

When I read that one of the objectives for this conference was to "develop recommendations for science education and careers in science for handicapped students," I was pleased, because having just been through the mill, I hoped that my practical experience could be useful to others. I acquired my entire formal education while in a wheelchair. Since sixth grade my major academic interest has been science; this culminated with a M.S. of Biology from the University of Illinois in October, 1977. From my multitude of experiences I have distilled two generalizations which I feel are applicable to most handicapped students. One generalization deals with science education, the other with science careers. I will elaborate on each in turn.

I acquired my entire formal education while in a wheelchair. Since sixth grade my major academic interest has been science.

As a scientist I am open-minded about, but always questioning, information I encounter. What are the assumptions? How were the data collected? Does the conclusion follow from the data? Observing everyday phenomena, such as rainfall, I wonder, How fast do raindrops fall? What determines raindrop size? How do raindrops form? I begin inventing hypotheses and then design experiments to test those hypotheses. Control experiments are essential to any test to reduce the possibility of spurious conclusions. This approach to questions follows the standard scientific dogma outlined for me yearly since about fifth grade. The question remains as to how that standard scientific approach actually becomes incorporated into a person's thought patterns. Which experiences in a student's education help him to think scientifically? In considering my own education, I firmly believe that my laboratory experience was the most profound shaper of my scientific ability. Therefore, Generalization I states: the first major obstacle for the handicapped student of science is getting the hands-on laboratory experience so important to engender scientific expertise.

I feel lucky indeed as I recall the variety of lab work which I performed in school. I have thought carefully about the factors which contributed to my successful scientific education; it all comes down to people—parents, administrators, teachers—willing to cooperate in my behalf. Realizing the value of scholarship, my parents took an active interest in my education. Active, but not pushy. Beginning in fourth grade I attended the local public school. For class field trips Mom would drive one of the groups to the museum, or to the nature center—for laboratories are not only found in schools. Dad went to all the parent's nights, talked with my teachers, and came home glowing about my progress. Impressed with my parents' interest and my ability, school administrators were wonderfully cooperative. For some of the administrators, I was their first and only handicapped student. One particularly memorable superintendent played musical classrooms with the three-story-no-elevator junior high school so that I could have those teachers who normally taught upstairs. Luckily, the science rooms were on the first floor—transporting gas lines isn't quite as easy as transporting globes. Back then, junior high science was mostly teacher demonstrations, and although science fascinated me, I had not yet gotten my hands into it.

■

. . . all of my parents' interest, and all of the administrators' cooperation would have been wasted were it not for enthusiastic science teachers who gave me the freedom to do as much as I could of what everyone else was doing.

That all changed in high school. There, all of my parents' interest, and all of the administrators' cooperation would have been wasted were it not for enthusiastic science teachers who gave me the freedom to do as much as I could of what everyone else was doing. Sometimes it only meant putting a microscope or analytic balance on a low table. Sometimes it meant rearranging the greenhouse so I could get down the overgrown aisles. In one case it meant encouraging this shy student to enter the state science fair and helping me choose an appropriate experiment which I could carry out myself. My teachers were the ones who ultimately placed science in my reach. I can't stress enough that their encouraging attitudes kept the You Can't Ogre locked out of my mind.

But we worked together, so my stubbornness and perseverance deserves some credit also. Science had piqued my brain; I was determined to learn as much as I could, actually *doing* as much as I could. I realized that if I wanted to do the acid/base experiments I would have to show that I could carry solutions around in my lap without spilling. If I wanted to firepolish my own glassware I had to show I could use a bunsen burner without setting myself aflame. If I needed to move a microscope to a lower table I had to show that I could do that without smashing it to smithereens. I had to prove myself all along the way, but my teachers accepted my physical abilities and, although I often caught a watchful eye on me, they did not stifle my enthusiastic investigations.

In summary then, my major recommendation for science education is to involve the student in lab experiments. Visual, auditory, tactile, olfactory, and gustatory clues can elucidate scientific principles; ingenuity and perhaps some extra work are all that's required. Ideally, teachers could contact a central office which collected and distributed experimental designs suitable for students with various disabilities.

Based on their experiences up through secondary school, some handicapped students will terminate their scientific meanderings in high school; others will embark on a scientific career. For the latter group Generalization II suggests: the most difficult challenge for handicapped students in science is to match one's mental capabilities and one's physical capabilities with a productive and satisfying career. Personal bias perhaps makes me single out this problem as the most crucial. I did acquire a good science education, but I have not yet totally succeeded in choosing a career which is both mentally satisfying and within my physical capabilities. I do feel that my personal experiences in science career seeking have several worthwhile take home lessons of value to all handicapped science students and those who counsel them.

■

In examining my entire science education, I note almost a complete lack of career counseling related to my physical abilities.

In examining my entire science education, I note almost a complete lack of career counseling related to my physical abilities. By pursuing a science education I realized that I could become a science teacher, a doctor, or that wonderfully nebulous creature called a scientist. Specific other careers were fairly unknown to me. Knowing full well what a science teacher and a doctor had to put up with, I opted to become a scientist fully confident that when I became one I would know what my job was. I maintained that painfully naive view to the end of my undergraduate years. As a senior I dove into the on-campus interviewing process applying for those jobs for which my coursework qualified me, mostly lab assistant positions. As interview after interview ended with, "It's been nice talking with you—we'll contact you if necessary," I realized I was going to be an unemployed biochemist (and moving back to the safe but suffocating home nest) if I didn't get my act together very soon. The point reached home that lab assistant jobs went to people who could reach all of the equipment and all of the chemicals, not to someone who could reach almost everything *if* the lab were modified. After some quick careful thinking about my employment problem, I chose to try hospital lab work, taking six additional months of training in cancer screening. My thinking paid off because, indeed, I had worked my way into a profession which valued intelligent, meticulous workers, and which had jobs located in hospitals (virtually always accessible). I was suddenly very employable; for two years that kept me going as the near fiasco at college graduation faded in my memory. The novelty of employment wore off though, and I realized whereas my job suited my physical capabilities perfectly, I was mentally very understimulated. I turned to graduate school, treated myself to a mental orgy, and earned a Master's degree. I'm now looking for that job which will use my mental and physical abilities to the fullest. I have more options with an advanced degree and I am more aware of what will constitute a satisfying job for me.

■

The handicapped student who is serious about studying science should be exposed, as early as possible, to the variety of jobs which are available in the sciences.

Certainly though, such a circuitous route to a career is not necessary or desirable; a few recommendations may help others follow a more direct course. The handicapped student who is serious about studying science should be exposed, as early as possible, to the variety of jobs which are available in the sciences. He should also be encouraged to think about what types of careers would be compatible with his particular handicap, or alternatively, how to overcome various physical problems which might arise in a less obviously compatible career. The AAAS Resource Group for the Project on the Handicapped in Science is ideal for providing career examples and role models for the handicapped student; I hope that pamphlets aimed at various age groups will be developed using the Resource Group as an information base. Such material could be distributed through the schools by superintendents, deans, teachers, and counselors. A little guidance at an early age can set the stage for continued mature planning throughout the student's education.

I also feel that the handicapped student must be encouraged to prize his mind and develop his mental abilities just as an athlete prizes and develops his body. The handicapped student's strongest asset in job competition is his mind; it is his responsibility to keep it sharp. In order to accomplish that the handicapped student should be cautioned to seek a career which will use those mental abilities fully. If an advanced degree is required for a desirable job, the student should prepare for those extra years. If a job loses its challenge, he should change. The handicapped person must learn to never sell himself short—unless he is willing to let everyone do it to him also. Choosing a career is a hard decision for everyone; for the handicapped student it can be especially frustrating and frightening. With some assistance in planning and some guidance in one's personal value, career choosing can be exciting.

Finally, let me emphasize that in this technological era science is a vital part of every child's education. Some young people will choose to pursue scientific careers. Some of those young people will be physically handicapped. I ask parents, school administrators, and above all, the teachers to let those students do all that they are capable of doing, show them their responsibilities to themselves, and open their eyes to the spectrum of scientific careers which exist. Your reward will be their success.

An Intervention Program for Occupational Stereotyping by Deaf Students

Judy Egelston Dodd
National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, New York

The handicapped face many barriers to successful career development in science and technology. The most notable include the lack of role models, deprivation of science content in their schooling, and discrimination based on negative societal expectations and personal aspirations. Deaf students must face all these and overcome the additional burden of a communication barrier.

There is abundant evidence of highly consensual norms and perceptions regarding males and females. The stereotypes attributed to men and boys are perceived to be more socially desirable and more advantageous to a person seeking a niche in the world-of-work of a scientific environment.

Many occupations in the United States have traditionally been divided according to sex, "men's work" versus "women's work."

Many occupations in the United States have traditionally been divided according to sex, "men's work" versus "women's work." Although men and women have recently entered fields where fewer than thirty percent of the jobs were held by someone of their respective sex, many technical and scientific occupations still remain dominated by one sex. Since the passage of Executive Order 11246 in 1965, very few occupations can be legally restricted by sex. However, if an individual feels that a particular job is inappropriate for his or her sex, that occupation is as good as closed, because he or she will not aspire to that job as a personally-potential occupation.

Junior high school-aged deaf adolescents are reportedly three times more likely to stereotype occupations by sex than are their hearing peers.

Deafness, like sex, represents a characteristic regarded by society as a handicap for holding certain jobs. Hearing-impaired students suffer not only the same curriculum deprivations that perpetuate stereotyping of occupations as their hearing peers, but they have also not had career education exposures which have been planned and implemented with their particular type of handicap in mind (Munson and Egelston, 1974). Junior high school-aged deaf adolescents are reportedly three times more likely to stereotype occupations by sex than are their hearing peers (Egelston and Kovolchuk, 1976).

Not only are deaf workers found in disproportionately large numbers among low paying, low status, dead-end jobs, but the majority of deaf students at both Gallaudet College and National Technical Institute for the Deaf are enrolled in programs traditionally appropriate for their sexual identity (Cook and Rossett, 1975). Both distributions show the effect of self-selection and aspiration based on traditional stereotyped notions of what deaf men or deaf women can do. Deaf adolescent women reportedly have a more traditional view of their sex role as manifested in vocational choices than do their hearing peers.

Freshmen at National Technical Institute for the Deaf rated jobs 1) as appropriate for males only, females only, or both; and 2) as appropriate for only hearing workers, only deaf workers, or both. Correlation analyses showed males tended to stereotype jobs by sex more than females, as expected since most of the technological majors represent pioneer choices for women. The strongest correlation (p.<.001) revealed that students who stereotyped jobs by sex also regarded deafness as a limiting handicap (Egelston-Dodd, 1977).

■

. . . students who stereotyped jobs by sex also regarded deafness as a limiting handicap

Intervention in these beliefs through science career planning seminars targeted at secondary school age deaf students could liberate their personal aspirations from the stereotypes of sex and deafness. A program for educators of the deaf which serves to raise their awareness of the detrimental effects of such channeling has its precedent in hearing schools where a deliberate attempt to overturn societal values and eradicate racism and sexism has resulted in response to Title IX of the Education Amendments of 1972. Such a plan in schools or vocational programs for the deaf, where stereotyping is even more rigid, has never been undertaken. It is past due.

For deaf people the effect of societal pressure to fit the doubly stereotyped occupational roles mandated by their sex and their hearing impairment is abundantly evident. The channeling of deaf males into machine or printing trades and of deaf females into keypunch operation or domestic duties is one result of the failure of schools and rehabilitative social and vocational services for the deaf to counteract the effects of this stereotyping.

■

The channeling of deaf males into machine or printing trades and of deaf females into keypunch operation or domestic duties is one result of the failure of schools and rehabilitative social and vocational services for the deaf to counteract the effects of this stereotyping.

The need for materials and strategies for a science career education effort which counteracts sexism and other discriminatory societal influences has been documented by Dr. Joanne Stolte, director of the NSF project, Science Career Development for the Deaf (1977). Deaf scientists, particularly females, are not readily available as role models. Schooling for the deaf, even through secondary level emphasizes language development to the exclusion of science content. The business community views with pessimism the difficulty, inconvenience and expense of communicating through an interpreter, learning manual communication and installation of teletype equipment to serve as telephone substitutes for potential deaf employees. The infeasibility and risk of a non-hearing handicappped person working with science equipment has been cited as rationale for the low participation of the deaf in careers in science and technology. The Philadelphia-based project proposes to provide successful role models, enhanced science content and positive expectations for career development in science in the hopes of stimulating scientific aspirations in secondary deaf students.

In light of such current development efforts, the design of a paradigm or philosophical context for the production of materials and strategies seems timely.

At the symposium entitled *Research and Utilization of Educational Media for Teaching the Deaf*, held in Nebraska in 1973, which focused on career education and innovative career and vocational learning activities, it was repeatedly shown that materials that work well with hearing students do not meet the needs for deaf students. Although they can be modified (captioned, edited, etc.) they do not offer the exposures and experiences which are essential in the education of deaf students. Rarely treated in sufficient detail are the kinds of work problems and attitudes which deaf workers encounter in the safety regulations, communications and human relations aspects of a job.

■

Rarely treated in sufficient detail are the kinds of work problems and attitudes which deaf workers encounter in the safety regulations, communications and human relations aspects of a job.

Munson and Egelston (1974) have reported a career education model which has been explicitly developed for intermediate and secondary level deaf students. The CREED model was explored as part of an action research and demonstration project in three New York State schools for the deaf. This project has resulted in the preparation of a program for meeting the specific career education needs of deaf students.

There are several general trends in the American job market which will combine nicely with structured and frequent career education experiences for deaf students and bring "pay off" in eventual human marketability. The major occupational trends that affect the employment of American people include 1) automation and the replacement of low-level, routine jobs by those requiring a high level of education and training, 2) technological developments which require sophisticated knowledge and skills, and 3) a growing realm of sub-professionals who perform the less complex tasks formerly carried out by doctors, nurses, teachers, counselors and others.

A number of recent developments represent changes which impact fortuitously on science career development for the deaf. These positive developments include 1) the tremendous success achieved by the National Technical Institute for the Deaf in providing skills and opportunities in many technical fields which were previously closed to the deaf, 2) public understanding of the deaf and their problems which has increased significantly during the past few years due to television, anti-discrimination legislation aimed at all minorities, and a growing national concern for making all handicapped fully participating members of American society, and 3) career education which is rapidly becoming a major component of the total educational process in our schools.

In order for these developments to augment the science career potential of secondary deaf learners, there must be a firm grasp of the theoretical framework underpinning the career education movement. Egelston-Dodd (1977) has summarized the field as revolving around four positions. On a narrow-to-broad continuum the first concept represents only the economic role of career education. Another position widely covered in the professional literature is the specific training required in the preparation for a job or some paid employment. The third conceptualization which is most compatible with an intervention program such as the one described in this paper, includes employability and occupational education but is not limited to the economic or work role. This position defines career education as a comprehensive self-development and career decision-making process approach. This concept evolves into position four, a life-time career development approach with the intent being an eventual provision for a total life-span tied to career development.

As we begin to view science career development in its broader, more encompassing dimensions, we are better able to accept it as vital for human maturation and intellectual development. Recent research on self esteem and self concept has suggested that children who have a positive self concept tend to achieve more. In the science education of deaf learners we should be able to keep in perspective the disability caused by hearing impairment and highlight the identification and development of each student's individual attributes and skills.

A science career education program can be infused into the existing secondary curriculum offerings using these four basic channels: 1) the *self,* 2) the *conceptual,* 3) the *informational,* and 4) the *experiential* (Munson, 1971). Briefly each of these can be differentiated as follows: *Self* exposures focus on the individual and his or her "being" and deal with the many component concepts of self that comprise the total self concept of the individual. Activities can be designed to provide deaf students with opportunities to explore their values, attitudes, abilities, aspirations, personally held stereotypes, and personal traits from the perspectives of their sex and the limits of their hearing handicap. Science classes represent an appropriate medium for teaching the analytic skills involved in such self evaluation (R. Egelston and J. Egelston, 1973).

Conceptual exposures contribute to the individual's general understanding of the nature of work, work functions and work roles, and also emphasize the development of attitudes and understandings that permit an individual to think abstractly about the role of work in their lives. Language serves an important function in conceptual learning. Deaf students need to understand the special vocabulary associated with the work function concepts. This vocabulary can be infused into instructional content units where the terms would be appropriately studied as part of the regular academic curriculum. Such work function terminology as negotiating, computing, and analyzing are already a part of typical science classroom experiences. Conceptualization of the tasks involved in a work situation may occur with repeated exposures and teacher guidance.

Informational exposures provide for input of a factual nature and deal basically with expanding students' knowledge about specific science-related jobs and career opportunities in the world of technical and scientific occupations. The informational channel must provide the very special information about job duties, work requirements and qualifications so that an individual has the needed knowledge for problem-solving and decision-making activities associated with his or her career development. Students *cannot* be exposed to all the career information which they may eventually need. They *can* learn how to locate information about the general duties of a job, typical work situations, the physical demands and conditions of an occupation, the personal qualifications and preparation requirements. Because the informational channel has a much stronger tradition in guidance and education in general, this material must be examined carefully for the stereotypes which could limit full career development in science. The failure to illustrate a mixture of males and females or handicapped and non-handicapped workers in the literature depicting a scientific career is a potent message to the reader which will impact on career decision-making. Teacher intervention involves bringing live role models of deaf workers of both sexes to the science classroom to serve as a direct source of career information, when they are available. If not, use of media which show an appropriate mixture of workers will help break the stereotypes.

Experiential exposures permit individuals to evaluate their feelings toward and skills in specific science-related jobs or work role relationships. This potent channel is rarely tapped in the typical science education program. Labor legislation has increasingly excluded the young from these real exposures, and economic conditions have limited part-time and summer work opportunities in any field. Although actual work provides *real* experience, life-like experiences of a simulated nature can be planned. Other strategies which can be employed to provide deaf students with experience in the actual dynamics of work include field trips to work sites, classroom and laboratory work, and homework assignments. In school deaf learners engage in work functions associated with data, people, and things. Schoolwork demands are real, and an individual's experience with these tasks, with the demands and pressures of completing these tasks and with the nature of the conditions in which the tasks must be accomplished, can be converted into meaningful experiential learning. Science teacher sensitivity to stereotypes regarding what deaf males and deaf females "can't" or "shouldn't" do must be displayed in the assignment of tasks so that engineering and physical science work doesn't go exclusively to the boys and record keeping or lab technician chores wind up assigned to the girls.

Women and especially deaf women (Connor and Rosenstein, 1963), are very aware of and sensitive to societal expectations. Therefore, another application demanded of any endeavor to enhance science career education is a model which works to undermine the stereotyping of jobs, interests and abilities according to rigid ideas of the limits imposed by sex or by possession of a handicap. Adherence to the guidelines established by the National Education Association's (NEA) recommendation for the elimination of sexism in curriculum materials is mandatory for the content, illustrations, language and philosophical base of any such program.

Finally, all of these changes depend on the positive and unlimiting attitudes of educators of the deaf toward sex roles and the handicap of deafness. Strategies for freeing educators of culturally derived biases have been developed for the hearing population through U.S. Department of Health, Education, and Welfare (HEW) sponsored programs. Infusing such strategies into the pre-service and in-service training of educators of the deaf can raise their awareness of the oppressive effects of stereotyping and demonstrate positive models of teaching behavior, counseling techniques and school policies which can intervene in sex-role stereotyping.

References

Connor, L. and J. Rosenstein. "Vocational Status and Adjustment of Deaf Women," *Volta Review,* December, 1963, 65 (10), 585-91.

Cook, L. and A. Rossett. "The Sex Role Attitudes of Deaf Adolescent Women and Their Implications for Vocational Choice." *American Annals of the Deaf.* 1975, 120, 341-345.

Egelston, J. and L. Kovolchuk. "Stereotyping of Occupations and Occupational Aspirations of Junior High Aged Students Using Parental Education and Occupation, Sex, and Deafness as Correlates." Paper presented at American Personnel and Guidance Association Annual Meeting, Chicago, Ill., April, 1976.

Egelston, R. and J. Egelston. "Self-Evaluation and Performance on Classroom Tests," *Science Education,* 1973, 57 (4), 525-531.

Egelston-Dodd, J. "A Philosophy and Paradigm for a Career Education Program for Deaf Learners," *Journal of Career Education,* III (4), 1977.

Egelston-Dodd, J. "Occupational Stereotyping," *American Annals of the Deaf.* 1977, 122 (5) 489-491.

Munson, H. "A Paradigm for Vocational Learning Maturation." University of Rochester, Unpublished paper. 1971.

Munson, H. and J. Egelston. *Career Development in the Education of the Deaf.* (Final CREED Report), University of Rochester, October, 1974.

A Visually Handicapped Student Prepares for an Education Career

Carmen Loperena
Salvation Army Day Care Center, New Paltz, New York

I am twenty four years old, of Puerto Rican descent, a graduate student in Early Childhood Education, and a part time teacher of a kindergarten class. My vision is 10/200; I am legally blind. I write this paper because I feel it is of importance to all educators, most particularly educators like a special education teacher I had in elementary school. When I graduated from her class she offered me words of advice. She said I would never graduate from high school and should forget about college. I can still distinctly remember banging my head against my desk until it was bruised and I passed out, because I was afraid of her reprimands if my answers were incorrect.

I was born a healthy, but premature baby. I was placed in an incubator at birth and unfortunately was given pure oxygen. This medical procedure probably saved my life. However, the retinas of my eyes were permanently damaged. Neither my family nor the educational system in my community was equipped to meet my needs. My parents, Puerto Ricans in Manhattan, were trying very hard to assimilate into the American society and I only made that process more difficult. When we went shopping I would pick things up in order to see them more closely. People would stare and my parents would yell at me. I was not allowed to bring friends home and almost always played inside.

Most of my teachers, with a few exceptions, were insensitive and uneducated to my needs.

In school I was in a "mainstreamed" program. I attended the regular public school classes most of the day. For extra reinforcement of skills, I also was in a "sight conservation" class. Most of my teachers, with a few exceptions, were insensitive and uneducated to my needs. The material was presented totally in written form, either in workbooks or on the chalkboard. Because I couldn't see the work, I fell behind. The teachers wouldn't let me move my chair in front of the board because then the others couldn't see. By the time the other children finished copying the boardwork, and I could start, the teacher would be on to something new. Math was particularly difficult because it was taught totally by writing math examples on the board. I could never finish copying my examples or my homework.

In junior high, science became my most difficult subject. Most of the science I encountered was handled by the teacher in front of the room, and I couldn't see. Sometimes a teacher would allow me to sit very close to her when she did the experiment. This only caused further embarrassment, however, because then the other students would frequently make fun of me. I was never allowed to help in cooking activities or pet care because the teacher thought I might cause a fire or endanger the animal. Frequently in biology, we used microscopes and drew diagrams. These kinds of assignments were impossible for me. I spent hours looking for diagrams that were large enough to copy.

Reading, Spelling, and Writing were of course difficult, too. Not only was it hard to discern the printed word, but English was also my second language and I sometimes needed translations. I tended to reverse certain letters in words, although I saw them in their correct places. Also, even when I used the dictionary, my eyes would misinterpret certain letters in the word and I would misspell the word anyway. It was difficult for my teachers to understand that it was not just that I saw less that fully sighted person, but that what I did see was blurry.

■

After graduating from high school with passable grades, I decided to attempt college.

After graduating from high school with passable grades, I decided to attempt college. At first I chose science as a major, but it seemed as if science was a visual field. After a semester of chemistry, which I failed, I changed my major to Education. I had worked with children in day care centers and at camp and had always enjoyed such work. I enrolled at State University of New York, (SUNY), New Paltz and began work in Elementary Education.

At first I told no one of my handicap. I was resolved that my life at college would be without embarrassments. However, when exam time came, I could not even finish one exam. It became necessary to tell my professors about my handicap. *It became necessary for me to accept my handicap if I wanted to succeed in college.*

Gradually I became aware of agencies that helped the blind student. Several of these agencies provided material, specially prepared for the blind. Perhaps they can be of benefit to others with handicaps like myself or educators working with visually disabled students.

■

With the acquisition of a monocular, a seeing eye dog, Maggie, taped books and large print materials, my college courses became a little easier and I really began to enjoy education.

With the acquisition of a monocular, a seeing eye dog, Maggie, taped books and large print materials, my college courses became a little easier and I really began to enjoy education. Unfortunately, Professional Core loomed ahead. Professional Core is composed of five methods courses and requires participation in a classroom. It is taken the semester before student teaching. Science was one of my methods courses and it again was a major problem. Our first assignment was to bring in an insect that crawled, hopped, or flew. This was difficult since I had never seen an insect clearly. A friend caught one for me and I brought it to class, however, I couldn't see it well enough to identify it. When the instructor discussed millipedes and centipedes, I couldn't tell the difference between the two words, nevermind the two animals. This didn't worry me too much, except that one of these two types of animals was possibly dangerous and I couldn't tell them apart. When the instructor went on to reptiles and amphibians, I thought the class would improve. After all, I did know what a turtle was. Unfortunately, the instructor discussed scales as a criterion and I didn't even know what scales were.

All my science experiences were not frustrating, however. There were moments I tremendously enjoyed, such as when we worked with electricity and later, plants. When I had materials I could touch and work with I was thrilled. Experiments to find "what will happen if . . . " that I could feel and view closely myself left me exhilarated.

■

I worked in a first grade classroom. When away from the pressure of books and actively involved with children I was happy.

My classroom participation was very rewarding, also. I worked in a first grade classroom. When away from the pressure of books and actively involved with children I was happy. And, I knew I wanted to give children the experiences of learning first hand, by active involvement themselves, that I had never had.

I looked forward to student teaching with mixed emotions. Although I knew I would be actively involved with children and that excited me, I was uneasy and frightened of failure. When I interviewed with my supervising teachers, they immediately made it known to me that if any limitations presented themselves in the classroom they would have to be designated on my certification. We also discussed the expectations that each of us had of student teaching. I learned my assignment would be two kindergartens; I would spend eight weeks in each. When I left the interview I felt a bit better.

The first few weeks of student teaching I observed the master teacher closely. There were times when I didn't understand her actions but I never asked questions, so as to appear intelligent. Later when I began to work with the children many of my questions were answered.

One of my fears had been that I wouldn't be able to see the children clearly enough to diagnose their needs. I soon quickly came to realize, however, that I was gaining a great deal of insight even with handicapped vision. I also felt good about my lesson plans. It was easy for me to motivate the children and get them involved in thinking.

One day a substitute teacher was in for the regular gym teacher. When I took the kindergarten class to gym, the substitute mistook me for the teacher. This incident gave me great hope. I was beginning to feel that I might actually become a teacher. For one of the few times in my life, I was beginning to feel like a success.

The Educator's Perspective of a Handicapped Student Teacher

Catherine T. Fosnot
Van Den Berg Learning Center, New Paltz, New York

When I was first approached by the coordinator of student teaching about having a visually handicapped student teacher in my class, my immediate reaction was no. I had recently had a baby and was trying to cope with family and work responsibilities together. I felt a visually handicapped student would need a great deal of work and time from me that perhaps I could not give. I also wondered, admittedly, how we could fully certify her to work with children. Would she really be able to manage a whole classroom of children alone if she could not see them? I consented to discuss these problems with her.

> *I felt a visually handicapped student would need a great deal of work and time from me that perhaps I could not give. I also wondered, admittedly, how we could fully certify her to work with children.*

At our first meeting, I was so struck by her fierce determination and drive that I immediately knew we had to accept this challenge together. Carmen openly faced her weaknesses and limitations.

In her previous education she had been given almost no phonic tools for sounding out words. Because of her visual handicap, she had also had limited experience with the printed word and therefore often mispelled words or reversed letters when trying to write down children's experience stories. Her printing was also difficult to read at times since her letters were not uniform; details were hard for her to discriminate. She could not read stories to the children, nor play a musical instrument. She felt insecure with arts and crafts, cooking, manipulatives, blocks, and environmental activities because she, herself, had had little experience with them. Visual discrimination and visual memory games were difficult. Yet all these activities were a large part of the kindergarten program. Management of the whole classroom and group meeting times were obviously difficult, also. From across the room she could see shapes, but no faces. The playground presented the same problems in an even exaggerated degree. I also worried about the presence of Carmen's seeing eye dog, Maggie, in the room. Would she knock over children's work, step on materials, or disturb children's play?

In some ways the limitations seemed insurmountable and yet I knew with Carmen's courage and determination, and a little creativity, from both of us, we could discover alternative methods of teaching.

■

Since she had been forced to find alternative methods of learning in school, she had developed an ability to solve problems creatively.

Carmen had strengths and talents, also, which we discussed. For years she had trained her memory to be an aid. She had learned to study by listening to tapes, to assimilate boardwork before it was erased, to remember details she might not see again. She was a very creative individual, also. Since she had been forced to find alternative methods of learning in school, she had developed an ability to solve problems creatively. Thirdly, she had tremendous drive. She was a hard worker and was willing to spend long hours in school, before the children arrived and after the children left. We decided to put her strengths to use.

To achieve successful management of the class, Carmen would arrive at school about an hour before the children and set all the activities up so that when the children began to arrive she could concentrate on what they were wearing, their body build, hair color and length, and the sound of their voices. This aided her in recognizing the children across the room and in the playground. She also kept her monocular close by in case she needed it.

At first, she had difficulty controlling her voice. When she felt she was losing control over the group her voice level rose. This only made the group more excitable. I suggested that she might possibly be trying to compensate for her blindness, assuming the children couldn't see or hear her since she couldn't see them. Once she realized the reasons for her behavior, change occurred. Together with the children she worked out signals to use when the class seemed to be getting too noisy or out of control. She flipped the lights to tell the children to "freeze." She could then focus them back in on constructive activity. I remember one day when the class was particularly "high." She flipped the lights and had all the children lay very still and told them a story about an island with no noise. The children instantly calmed to the sound of her voice.

Sometimes when there were special projects planned, Carmen would utilize a tape recorder. Since she was familiar with the tape recorder as a teacher, she used it as a teacher for the children too. She devised a lesson that was self-directed and self-corrective. That enabled her to move around and work with the other children.

In the beginning of her student teaching experience she worked only with small groups in cooking, blocks, manipulatives such as lincoln logs or tinker toys, and arts and crafts. This gave her a chance not only to get to know the children, but also to have some first hand active learning experiences herself. Soon she began to feel at ease with the materials and really enjoy the process of education for she was experiencing the joy of learning along with the children.

■

Today I think it would be impossible to discern Carmen's written work from mine.

Hard work was the key in developing better printing. Carmen spent long hours practicing printing neatly and uniformly on lined paper. Today I think it would be impossible to discern Carmen's written work from mine.

To develop better phonic skills, Carmen and I sounded out words together. I helped her break the word into syllables and try to spell it instead of spelling it for her. She also used the dictionary frequently. This was a great learning experience for the children, also.

Carmen familiarized herself with Parquetry blocks as a method of teaching visual discrimination skills. By using her sense of feel she could determine if the child had reproduced the pattern correctly. She also prepared extensive games and visual materials to use that were large enough for her to see.

Story time, however, remained an obstacle. Carmen could not read to the children. Finally her creativity blossomed. One day she had the children paint pictures of their favorite animals with fluorescent paint. Then she asked them to tell her something about their pictures. She put their responses on tape and bound the pictures into a book. The next day at story time the children listened to their talking book and looked at it under a black light. Since then she has used flannel board stories, records, and even memorized large print books.

Maggie, Carmen's dog, never presented difficulties. The children immediately fell in love with her and she became an integral part of the class.

As the period of student teaching drew to a close, Carmen and I began to discuss her future plans. Although she had made tremendous progress and I felt she could manage a classroom alone, there were areas in which she still felt weak. She decided to continue her education on the graduate level in Early Childhood Education and requested to work part time with me in the classroom. Taking theory courses and being able to implement it in the classroom seemed ideal.

Today as I view Carmen working with the children in the class she seems a teammate rather than a student. Observers walk into my classroom and find it hard to believe she is blind.

Today as I view Carmen working with the children in the class she seems a teammate rather than a student. Observers walk into my classroom and find it hard to believe she is blind. Frequently she substitutes for me. We know the future will still be rocky; she will have to deal with attitudes of the public and administration. But, with her determination I know she will succeed.

Carmen has gained a lot from our experience together but I feel I have also. She taught me new ways to approach teaching and helped me develop a sensitivity to the handicapped. But, most of all I've gained a close and dear friend.

Considerations for Developing Science Education Programs for the Handicapped

Robert E. Rehwoldt
Student Oriented Programs, National Science Foundation, Washington, D.C.
Judith H. Samoff
Division of Natural Sciences, Marist College, Poughkeepsie, New York

The underrepresentation of the handicapped in science careers can be traced to a number of causes. Perhaps the most obvious of these causes is the lack of effort on the part of government, industry and education to recruit this minority. This statement should not be construed as a damnation of these sectors nor a demand for reparations for past years of neglect. It is probably true however, that this lack of policy has deprived our country of the services of some very talented people.

The creation and implementation of a policy is not an easy task but neither is it impossible. The policy must be very specific in purpose although not necessarily in tactics. The overall objective must be to create paths and opportunities for the handicapped to enter science careers if they choose, but yet not entice them into areas in which they may only have borderline or marginal interest.

The overall objective must be to create paths and opportunities for the handicapped to enter science careers if they choose, but yet not entice them into areas in which they may only have borderline or marginal interest.

One approach to this end will be tested at Marist College through a National Science Foundation funded project. The thrust of the project is to recognize that there are restrictions related to disability and restrictions arising from misconceptions concerning careers in science.

It is imperative that the handicapped be helped to distinguish between these two types of factors. It is only after such a determination is made that an individual can formulate realistic career goals. When unwarranted hesitancy on the part of a potential employer, or an undue lack of confidence on the part of either the handicapped or the non-handicapped are permitted to exaggerate the negative effects of physical disabilities, science may be deprived of potentially valuable contributions and a handicapped person may be denied a challenging and productive life.

It is usually during the latter part of an individual's secondary school experience that the first serious decisions are made regarding career alternatives. Certainly the decision of whether or not to attend college is an issue during the last several years of high school. For the handicapped and non-handicapped alike, these decisions are based on self-assessments—analyses of individual needs, desires, and capabilities—and on evaluations of the potential benefits and the potential negative aspects of various careers and of various post-secondary educational options. Again in the case of both handicapped and non-handicapped high school students, self-assessments are derived primarily from past experiences, and from the judgments and expectations of teachers, peers, and family of the student's performance in various spheres of activity. The student's perceptions of various careers and post-secondary education, too, are strongly influenced by the views and beliefs of others.

For non-handicapped students, the experiences and judgments of other people can be valuable tools for decision-making. For handicapped students, however, such second-hand advice can prove to be detrimental to accurate self-assessments and to a clear analysis of the requirements of different careers. Stereotypical notions of limitations are often wrongly imposed on handicapped individuals and can prevent them from making choices which would have enabled them to reach high levels of self-esteem, career success, and professional achievement.

■

Stereotypical notions of limitations are often wrongly imposed on handicapped individuals and can prevent them from making choices which would have enabled them to reach high levels of self-esteem, career success, and professional achievement.

In addition to the opinions of others, the handicapped high school student may have been further discouraged by negative experiences which have actually occurred. Most high school science laboratories are not constructed so that the physically handicapped student can participate in experiments. Limited resources and a lack of imagination may have actually prevented handicapped high school students from experiencing science in a positive and constructively challenging fashion.

The primary goal of the program at Marist is to enable participating physically handicapped high school juniors and seniors to accurately judge their own interests and abilities in science and its potential as a career, based on a representative experience in science and based on relevant direct information from career scientists and science faculty members. It is our intention to field-test a program which will provide such opportunities not only to handicapped high school students who participate in the project at Marist, but also to handicapped students in other areas of the country. We will achieve this national impact by designing the project in such a way that it can be easily replicated at other postsecondary institutions.

■

. . . to accurately judge their own interests and abilities in science and its potential as a career, based on a representative experience in science and based on relevant direct information from career scientists and science faculty members.

In order to achieve the above-stated goal, the specific objectives of the proposed program at Marist College are:

A. To provide approximately 20 physically handicapped high school juniors and seniors with an opportunity to participate directly in a meaningful and relatively comprehensive program in science;

B. To provide participating students with information about careers in science in order to make them aware of the requirements—both physical and academic—of various scientific occupations, and of the potential rewards in these career areas. The information provided will include a description of scientific careers which are not laboratory dominated but which do require an understanding of scientific methodology;

C. To provide participating students with an experience in campus living and with an exposure to successful scientists who are handicapped and to successful college students who are handicapped;

D. To provide approximately six non-handicapped college science majors with an opportunity to participate in a summer science program, while at the same time gaining skill and experience as paraprofessionals prepared to work with handicapped individuals; and

E. To conduct a stringent program evaluation, revise elements of the program as appropriate, and prepare a project manual which can be used by other postsecondary institutions in the implementation of similar programs in science for handicapped high school students.

While this project may have some degree of success there is a more subtle and perhaps less easily addressable problem with attracting handicapped to science careers.

One of the strongest driving factors in a young handicapped person's life is to blend in with the mainstream of his peer group. Any teenage insecurities are magnified by the knowledge that he or she is different and must receive special attention which in turn calls further attention to the difference of disability.

The choice of a career in science in itself is not a mainstream decision. It is viewed right or wrongly, by the majority of the population as a career area which attracts students who are somehow less outgoing or relaxed and more withdrawn and serious. In short, science majors have been labeled as different by their career choice. How much this perception of the able-bodied science major may effect the career choice of the handicapped is yet to be evaluated. Certain tactics such as role models may alleviate the problem.

One consideration that must never be overlooked is that to assume that percentage representation in the science based upon the percentage of handicapped in society would be grossly in error. To do so would be to deny genetic variation which must apply to all segments of the population.

Attracting Handicapped Students to College Careers in Science

Heidi Fawber,
Harry N. Ash,
Howard T. Blane,
Debra Boots,
Margaret A. DeMichele,
G. Edward Denslow,
Richard E. Desmond,
Linda E. Hewitt,
Debbi Swazuk
University of Pittsburgh, Pittsburgh, Pennsylvania

. . . perceived opportunity affects educational and occupational attainment.

The purpose of this paper is to report progress to date of a project based on the notion that perceived opportunity affects educational and occupational attainment. The project is designed to test a global method of influencing perceived opportunity structure among severely disabled high school seniors who show academic ability to further their education. This global method has several aspects:

1. We encourage students to apply for admission to college and offer them assistance in the application process.
2. We invite them to the University of Pittsburgh campus for a week-end during which they meet and talk with college students, both handicapped and nonhandicapped, and faculty representatives to gain an impression of college life and how it can accommodate handicapped students.
3. During the week-end visit, students also meet and talk with severely disabled career models—successful administrators, doctors, engineers, and so on.
4. We provide academic and career counseling based on students' aptitudes and interests in the context of a voluntary, continuing relationship.
5. We reduce social and physical barriers against mobility and communication and attempt to create an atmosphere which encourages the freest expression of personal abilities and talents.

The project is being conducted within an evaluation framework that will allow us to draw inferences about the effectiveness of the method being used. Specifically, we have systematically selected severely disabled high school seniors who are receiving services from the state Bureau of Vocational Rehabilitation (BVR) and who have an average or higher I.Q., good high school grades, SAT scores above 750, and/or rank in the upper third of their

---

* *The preparation of this paper was supported in part by a grant from the National Science Foundation.*

class. We have a complex definition of severe disability; simply stated, it refers to impairments from any cause of hearing, sight, skeletal structure, or musculature which affect physical mobility, affect ability to manipulate objects, and/or interfere with communication of information. Selected students were randomly assigned to either a treatment or nontreatment group. Both groups are to be assessed before and after treatment on measures of perceived opportunity, vocational interests, and work values. In addition, we are obtaining relevant social background information and outcome data regarding college admission and enrollment. We are predicting that after one year, treated students will show greater increases in perceived opportunity measures than untreated students and that more treated students will be enrolled in college than untreated students. Information collected in subsequent years will be oriented toward choice of science majors and science careers.

With this brief description of the project in mind, we want to report today concerning early findings in three areas: subject selection, treatment, and development of measures. The areas of subject selection and treatment, in particular, have implications that go beyond our project and relate to recruitment of handicapped persons into science fields generally.

Our original plan was to obtain computer listings of all high school student BVR clients and to screen the lists for students who met our disability criteria. We then intended to obtain information about academic ability from the client's BVR counselor or school guidance counselor. From the resulting list, we would randomly assign clients to treatment or no-treatment conditions, and contact them accordingly. While we continued to rely on this procedure, it proved to be sufficiently cumbersome and problematic that we developed other procedures to identify severely handicapped students.

Problems in Sampling

Mention of some of the difficulties we have run into may serve as a cautionary tale for others who need to systematically sample populations of severely handicapped persons. The problems were threefold and involved (1) the quality of the computerized data base, (2) discrepancy between our definition of severe disability and that based on federal standards used by BVR, and (3) adherence to rigorous but necessary confidentiality procedures.

Data Base. Sixteen district offices report client data to a central office computer. Seniors in high school usually don't begin to apply for BVR aid until late fall or winter of the senior year. Allowing for normal delay in getting this information coded meant that information about many seniors was not available in time for us to screen computer lists, identify clients appropriate for the program, obtain confidentiality clearance, and get the client into our program so that we could be fully of use to her/him. Further complications include individual variations among offices in the manner in which data are coded. For example, one office only infrequently used the code for high school students, preferring to code most high school clients as intakes. Another office submitted client data periodically rather than continuously, so that codes were often out-of-date.

Definitions of Severe Disability. Disability codes used by states are based on Federal definitions developed by the Rehabilitation Services Administration of HEW. While we had few problems with codes for visual or auditory handicaps, codes for orthopedic and other conditions provided little information about the extent of functional impairment. In order to make clear-cut statements in this regard, we found it necessary to contact district offices and individual counselors. This placed another time burden on subject selection. A separate code for severe disability used by BVR was defined more broadly than our definition, but did prove useful when clients with mental retardation and other mental/social handicaps were screened out.

Confidentiality Procedures. During the entire process of subject selection, we dealt only with client I.D. numbers in order to preserve confidentiality. Once a client was selected for the project, we submitted his number to the central office. From there, letters describing the program and inviting the client to participate in it were sent to the client and to the client's parents; these letters requested parents and client to sign a form authorizing BVR to give us the client's name and address and to share information in the client's folder. Only after the signed release form was returned to the central office did we know who the client was. This completely necessary procedure proved to be cumbersome, time-consuming, and subject to communicational error. Further, the necessity to preserve confidentiality prevented us from obtaining information about intellectual ability from schools when this was not available in a client's BVR file. This placed additional burdens on BVR counselors to obtain this needed bit of information.

As some of these difficulties became apparent to us, we began to explore other means of recruiting students to the project. We had already been in contact with the model school at Gallaudet College, and we stepped up this effort. In addition, we sent letters to public, parochial, and private secondary schools in the greater Pittsburgh area and to large communities in Western Pennsylvania. These letters explained our program and indicated how school counselors, students or students' parents could contact us directly. While this was a less systematic way of proceeding, it short circuited the selection process involving BVR client lists.

■

. . . it is probably better to begin the process of facilitating transition from high school to college in the latter part of the junior year instead of during the senior year.

These observations should not be taken to signify that State BVR's represent a poor means for recruiting promising youngsters to science careers. To the contrary, BVR's clearly deal with the largest number of handicapped students. If recruiting efforts were accommodated within State BVR's, many of the problems of accessibility of records and confidentiality procedures would be automatically solved.

One other observation: on the basis of our experience so far, it is probably better to begin the process of facilitating transition from high school to college in the latter part of the junior year instead of during the senior year. This allows time to take medical, social, ability and interest factors into account in choosing the institution most suited to the individual student.

Treatment

Our progress to date on program development has, for the most part, been very encouraging. University receptivity to severely disabled students in science has been mostly favorable, and there are existing services on campus that dovetail neatly with aspects of our program. The University has an office for handicapped students which is run by a blind staff person; this office serves as a fulcrum for advocacy of social and physical changes in the University to facilitate education for disabled students. Further, we have a BVR counselor on site at the University who is responsible for BVR clients enrolled here; she works out of our program offices.

Administrative support has been consistently present. For example, the Assistant Dean of Alumni Affairs, a long-time advocate for the handicapped, represented the administration during the on-campus visit of prospective students.

Many key individuals on science faculties also support the program. An astrophysicist is developing a summer program which includes a lab program for high school students as a transition to college. She is desirous of including disabled students and making modifications in equipment or devising organizational means to provide the highest level of training. On the other side of the ledger are faculty members who believe that scientific work, particularly as it involves laboratory manipulations, is not possible for students who are blind or confined to a wheelchair. They view deaf students as more able to master lab procedures but unable to grasp material presented in lectures. However, none would attempt to keep a student from registering for one of their courses, although they would not be likely to make accommodations for disabled students in their classes.

■

. . . living proof that the opportunity structure is more open than many disabled persons have been led to believe.

Our attempts to recruit successful career models proved to be extremely fruitful. There are a number of highly successful administrators, engineers, physicians and others who graphically portray the rewards to be gained by the severely handicapped person and the problems s/he faces in attaining educational and career goals. They are living proof that the opportunity structure is more open than many disabled persons have been led to believe.

■

Everyone sees the need for curb ramps and related mobility facilitators. But the need for interpreters, audio texts, Braille texts, appropriate examination forms, and other communication innovations is often less clear . . .

Our experience thus far suggests that universities are generally receptive to severely disabled students and are prepared to make modifications in the social and physical environment that make educational opportunities as open and accessible to disabled as to nondisabled students. The matter appears to be largely one of education. Everyone sees the need for curb ramps and related mobility facilitators. But the need for interpreters, audio texts, Braille texts, appropriate examination forms, and other communication innovations is often less clear—not necessarily because of prejudice, but because of lack of knowledge about the implications of different handicapping conditions.

Development of Measures

We are measuring vocational interests and work values with standardized instruments of known reliability and validity. The Strong-Campbell Interest Inventory (Campbell, 77) measures vocational interests, and the Work Values Inventory (Super, 1968) measures work values. Because of previous work on these tests, pilot studies were not necessary.

Our measures of perceived opportunity are based on work by Jessor and associates (Jessor, Graves, Hanson, and Jessor, 1968) and include three instruments: a personal values questionnaire, an expectations questionnaire, and a life chances inventory. The first two focus on relatively immediate goals in the peer group and in the school situation, whereas the life chances inventory is designed to tap more distant goals and values. While some psychometric work was done in the early 1960's on concurrent validity and internal consistency of the values and expectations questionnaires, the results are now outdated; further, the test-retest reliability characteristics of the questionnaire are unknown. As for the life chances inventory, we have revised and lengthened the original version of it, so it is in essence a new measuring device.

In order to assess the internal consistency, time reliability, and concurrent validity of these instruments, we administered them, along with some questions inquiring about social background information, on two separate occasions two weeks apart to a sample of 47 female nondisabled high school juniors.

The findings for the girls indicate that internal consistency as measured by coefficient alpha is acceptable for all three scales, ranging from .84 to .96. Test-retest reliabilities were .80 and .93 for the personal values and expectations measures, respectively, and .75 for the life chances inventory. While the latter figure is on the low side, it is nevertheless acceptable, considering the fact that this scale consists of only 10 items and is based on 47 observations.

Concurrent validity coefficients for personal values were in the expected direction when self-reported scholastic achievement (grades) was the criterion and, though they were not high, ranging from .25 to .57, all were statistically significant. When family socioeconomic status (SES) was the criterion, there were no significant correlations, although most were in the expected direction. The life changes inventory showed no significant relationship to either grades or SES, although correlations again were in the predicted direction. The findings concerning the validity of the instruments were not as strong as we would wish, but are nevertheless generally in the predicted direction (we plan to test a group of high school boys to obtain this data).

In summary, we have presented the rationale, operations, and some findings to date concerning means for identifying intellectually promising severely handicapped adolescents and for helping them to achieve their vocational goals. As we continue to work with these students in their college careers, we will actively support and encourage those with scientific interests and science career objectives to obtain the education they require to realize these objectives.

References

Campbell, D. P. *Manual for the SVIB—SCII Strong-Campbell Interest Inventory,* Second Edition. Stanford, CA: Stanford University Press, 77.

Jessor, R., Graves, T. D., Hanson, R. C., and Jessor, S. L. *Society, Personality, and Deviant Behavior.* New York: Holt, Rinehart and Winston, 1968.

Super, D. E. *Work Values Inventory.* Boston: Houghton Mifflin, 1968.

Science Career Information for Physically Handicapped Individuals

Neal H. Berger
Thomas County Schools,
Thomasville, Georgia

What can the physically handicapped do? Well that's like asking, "What can a 1,000 pound gorilla do?" . . . Anything he wants to! Handicapped people can and *are* already functioning successfully in numerous science careers that many people previously thought were impossible, or just for the non-handicapped. Blind electrical engineers, deaf biochemists and individuals like a research surgeon with no legs and opposing digits on his only hand, are successfully participating in science careers

Many times, we as educators and counselors have played-down or discouraged the handicapped from entering the world of work in science. Rarely, have scientists discussed with me the encouragement that a science teacher, vocational rehabilitation counselor or school guidance counselor has given them. The handicapped scientists, with whom I have spoken throughout this country, have indicated that the greatest handicap that they have to overcome has been the attitudes of *others*, and not their own physical handicap. There are perhaps thousands of people with orthopedic, visual and hearing handicaps, with excellent abilities in science, who are now working at jobs such as broom making. Many of these people might have provided a new technique or discovery to revolutionize our world.

■

Handicapped people can and are already functioning successfully in numerous science careers that many people previously thought were impossible, or just for the non-handicapped. Blind electrical engineers, deaf biochemists and individuals like a research surgeon with no legs and opposing digits on his only hand . . .

Our objective in Thomasville, Georgia has been to provide useful information on about 210 science-related careers which could be of value to anyone, handicapped or not. Quite intentionally, we have not said whether someone should or should not consider a particular career. Rather, we have tried to design career guidance information which will not single out an individual simply because of his/her handicap. It has been the judgment of many members of our national handicapped science advisory board, and consultants, to provide the right kind of information so that an individual with good decision-making skills, can decide for themselves.

■

Quite intentionally, we have not said whether someone should or should not consider a particular career. Rather, we have tried to design career guidance information which will not single out an individual simply because of his/her handicap.

The purpose of Project SCI-PHI is to provide an integrated science-related career guidance system which will encourage and assist physically handicapped individuals to undertake science-related careers. The target population in this project includes junior high students through adults, with orthopedic, visual and hearing handicaps. Project SCI-PHI is supported in part by a National Science Foundation grant under their Handicapped in Science Program, 1977-78.

SCI-PHI, which is an acronym for Science Career Information for the Physically Handicapped Individual, is a complete set of career guidance materials which are appropriately designed for the specific needs of the physically handicapped. The content, format and approach has been endorsed by the project's National Science Advisory Board, which is composed of over 30 handicapped scientists, nationally known educators, and vocational rehabilitation experts from the Georgia Department of Human Resources.

Prior to developing the materials, a national telephone survey was conducted to determine the need for developing a science career guidance system for use by field and public school counselors, science teachers and rehabilitation specialists, who work with the physically handicapped. Almost without exception, these institutions, agencies, and individuals stated that such materials were non-existent and further, appropriate science-related career guidance materials could act as an indispensable resource from which many other guidance services and career decisions could evolve for the physically handicapped.

Following this assessment phase, we have contacted hundreds of handicapped and non-handicapped scientists throughout the country for assistance in this project. The response has been extraordinary! Many handicapped scientists have provided taped interviews and many other contacts by phone and letter have provided us with excellent input for the SCI-PHI Project.

Some of the products resulting from this input include: filmstrip/tapes, Braille career information, an audio library, and over 200 science career briefs in hard copy and microfiche formats. Each of these components will now be explained.

The first component we will examine is the filmstrip/tape series. Here interested students have a choice of viewing ten different filmstrips. Fifty people in science-related careers were interviewed and photographed on-the-job to assemble this particular program segment. Students are offered a basic job description, while simultaneously seeing and hearing or reading about the individual depicted. In addition, the scientist offers his/her suggestions concerning coping strategies, motivational factors and how s/he feels about his/her career.

Students are offered a basic job description, while simultaneously seeing and hearing or reading about the individual depicted. In addition, the scientist offers his/her suggestions concerning coping strategies, motivational factors and how s/he feels about their career.

Approximately 900 pages of Braille in ten volumes offer the visually handicapped users a chance to explore the 200+ science careers. These 10 volumes will provide complete job briefs covering such topics as: DOT Number, (six and nine digit codes), a general job description, probable working conditions, educational background needed, opportunities for advancements, worker characteristic traits, and finally a look at wages. In addition a tape with coping strategies and additional information for the visually handicapped are included. Accompanying the volumes of Braille will be a complete set of cassette tapes which permits all users except the deaf, to explore the same 200+ science careers.

To further expand the use of these materials the printed copy of all 220 career briefs has been included. A typical career brief consists of four pages of information which is written on a 5th to 6th grade reading level, and has been printed in 18 point, large print type. Each of these briefs contain the same information as described for the Braille and audio cassette materials.

Since there may be a handling problem in using the more bulky job briefs, we decided to also provide a set of microfiche cards for potential users. By using microfiche, 1,000 pages of information has been reduced to 15, 4"x6" pieces of film which can easily be enlarged in a reader device. The microfiche is identical to the hard copy briefs.

As a means of encouraging the handicapped into science careers we have also developed a series of T.V. and radio public service announcements. Two and one minute, 30, 20, and 10 second T.V. shots have been produced. These will feature actual handicapped scientists.

In closing, there are many intricate and interesting details that I would like to share with those interested in this project. Insights into the surveys, interviews with the scientists, and even the process of compiling all this information on such a tight budget and time-line, can be interesting. However, this will have to be for another time.

Mistakes have been made, but to be honest to you and myself, we have assembled a wealth of data that has never been collected before. In a sense we have only scratched the surface of science career information for the handicapped. We hope that by pilot field testing these materials this Spring, we can provide a variety of ways in which these materials can be effectively used and improved. We hope to locate additional funding sources to provide for additional field-testing, product revision, updating and the addition of more valuable features.

10

Science Education and the Handicapped:

Some Implications for the Future

10

Science Education and the Physically Handicapped: Implications for the Future

Kenneth S. Ricker
Science Education, University of Georgia, Athens, Georgia

In the opening chapter the state of the art on science education and the physically handicapped is presented. In addition, recommendations resulting from the Conference on Science Education for the Handicapped Students, conducted by the National Science Teachers Association, are given. Chapters two through nine provide background to support these recommendations.

The recommendations focus on the future of science education and the handicapped. This chapter identifies implications for each of the seven categories of recommendations.

Teacher Education

. . . the education of handicapped students permeate the total teacher education and counselor programs.

The most important aspect of this category is the recommendation which acknowledges the importance of having the education of handicapped students permeate the total teacher education and counselor programs. The recommendation points to the need to increase the "sensitivity to and awareness of the unique needs of physically handicapped students as well as the needs of students with other special learning needs in science classes, while emphasizing the similarities to non-handicapped students." If this one recommendation could be accomplished it would probably mean more to achieving the goals of educating handicapped youngsters than any other single thing. Not only would the education of handicapped students be improved immensely, but the education of all students would be greatly enhanced. Educators would recognize that all students do not learn science in the same way; and that they could think of PL 94-142 as entitled the "Education for ALL Children" and not the "Education for All Handicapped Children." In addition, the practice of using labels that tend to erroneously stress differences between students would cease. For example, visually handicapped youngsters would be viewed as being more like non-visually handicapped students than being different.

The recommendations recognize the need for pre-service training without specifying how it should be accomplished. There are already several ways now being tried throughout the country. Each way has its own merits. Only

Only time will tell what kind of pre-service program is the most advantageous and under what conditions. In the meantime it is critical that a variety of ways be attempted and carefully monitored.

time will tell what kind of pre-service program is the most advantageous and under what conditions. In the meantime it is critical that a variety of ways be attempted and carefully monitored.

In some pre-service programs the scope of the regular science methods course may be broadened to include the education of handicapped students. Thus, the concept of normalcy of the student population is broadened. In other words, it will be normal to anticipate having a handicapped student in a science class.

In other programs the prospective science teacher may take a general introductory course in special education. This course will be taught by a special educator.

Other teacher educators may try a team approach between special educators and science educators. In this situation the prospective teachers will meet with a special educator to obtain the basic and general information on the education of handicapped students; and then meet with a science educator to discuss this information as it relates to teaching science. In addition, science programs, instructional strategies and materials will also be examined.

In some pre-service programs a special education science methods course will be utilized. In this situation the instructor will probably be a science educator. Prospective science teachers will be exposed to the basic information on the education of handicapped students and its relationship to teaching science simultaneously.

It is recommended that pre-service teachers have an opportunity to work with physically handicapped students. This recommendation may be difficult to achieve. There are low numbers of physically handicapped students in comparison to the number of prospective science teachers, particularly in non-urban areas. A possible alternative to this problem may be the following: arrange opportunities for prospective science teachers to work with handicapped people in general, not just students in a K-12 school setting. Probably the most significant aspect of this practicum is to help the prospective teacher to learn that handicapped people are "regular" people; to learn that due to a physical impairment modifications in their lives are necessary; to learn that every person with a similar physical impairment does not necessarily make the same kind or degree of modification.

Methods

The inclusion of a physically handicapped student in a science class should not necessarily alter the natural setting of the class. It is apparent that some modifications will be required to meet the unique needs of handicapped students. For example, a blind student may use a braille writer in the classroom; an interpreter may accompany a deaf student to the class; and a special work table may be put in the classroom for an orthopedic handicapped student. Initially all of these things would alter or modify the normal appearance and procedures of the classroom environment. However, as time passes this concept of normalcy of the classroom environment should change for both teachers and students. They will come to accept these kind of changes in the classroom as part of the normal setting.

■

Teachers should help the handicapped students become independent learners and problem solvers so they can function more effectively in the "real" world.

■

continuously guard against the possibility of over-adjusting to handicapped students

Several of the recommendations in this category relate to the way teachers should work with handicapped students. Teachers should help the handicapped students become independent learners and problem solvers so they can function more effectively in the "real" world. This will be a difficult task for regular classroom teachers, yet one of the most important tasks they face. It is essential that these teachers receive adequate and professional assistance in formulating a plan of action for each handicapped student. Science teachers should not have full responsibility for making decisions on the kind and number of modifications that will be necessary in the science instructional program. Actually the handicapped student should also participate in the decision-making process whenever feasible. The decision-making process should continuously guard against the possibility of over-adjusting to handicapped students. Handicapped learners should not become dependent on a system which is constantly modifying itself to accommodate their needs. In this system the handicapped students will be less likely to gain the attitudes, skills and practice necessary to adjust to conditions outside this system in the real world which is much less accommodating.

■

The capricious use of double standards is neither fair to the handicapped students, their parents, other students nor society in general.

Teachers will have to guard against the growth of double standards. Because a student is handicapped does not mean teachers should automatically expect these students to do less than a non-handicapped students with comparable capabilities. The capricious use of double standards is neither fair to the handicapped students, their parents, other students nor society in general.

Teachers should consider the use of multi-sensory science activities. These kinds of activities will permit handicapped and non-handicapped students to participate in the same activities. The use of multi-sensory activities may also be beneficial to students who are categorized as non-handicapped. For the most part science instruction has depended heavily on one sense, vision. It has been assumed that all non-handicapped students are equally proficient in learning by the visual modality.

Materials/Programs

■

Efforts should be directed toward the development of ways to eliminate the barriers which are preventing accessibility to existing science programs and curricula.

Many of the recommendations are related to curriculum and program development. In this regard science educators should be cautioned about developing science programs or curricula that are *for* the blind, or *for* the deaf, or *for* the orthopedic handicapped students. These students should be in the same science programs as the non-handicapped students. Efforts should be directed toward the development of ways to eliminate the barriers which are preventing accessibility to existing science programs and curricula. In addition, the development of any new science programs should be required to take the needs of handicapped students into account so the new programs are automatically accessible. Commercial developers of programs and instructional aids should be urged to take handicapped students into consideration. At present, visual orientation governs the production of many commercial products.

The recommendations that are concerned with the need for non-science type services are extremely important. Without these services it will be very difficult, if not impossible in many cases, to implement the desired modifications in the science program.

One recommendation deals with the use of handicapped scientists as role models. This idea is worthy of careful study. Such parameters as what type of role model works in what type of situation; what students benefit from; what is the crucial stage of their educational career, should be examined in detail.

Dissemination

■

. . . the necessity for educators to have on-going access to current and relevant information.

The recommendations on dissemination recognize the necessity for educators to have on-going access to current and relevant information. But how can this be accomplished? Perhaps an agency could be established that would serve as a clearinghouse on science education and the handicapped. Such a clearinghouse could be a multi-purpose agency, and could also have regional or state branches. The central clearinghouse could coordinate the acquisition and dissemination of knowledge about teaching science to handicapped students; the preparation of science teachers to work with handicapped students; exemplary science programs which are barrier free to handicapped students; and science-related career education materials. Both the central and regional clearinghouses could serve as a crisis-line to any science teacher in the country who has never had a physically handicapped student in his/her classroom but is now facing that situation. Although this teacher may have had some preparation in his/her pre-service teacher education program s/he now wonders what new things have been developed in the three years since s/he has graduated.

■

The clearinghouse could keep track of requests for specific kinds of aids or assistance. These data would serve as the basis of directing developmental efforts for aids and instructional modifications that are non-existent.

The regional clearinghouses could also serve as lending resource centers. Suppose a science teacher in a rural school district needs a liquid level audio-sensor for a blind student to use in the lab portion of the course. The school has never had a blind student before so does not have the sensor. In addition, the school does not foresee having another blind student in the immediate future. Therefore, rather than having this school purchase the sensor and having to store it indefinitely after being used one year, the school could turn to the clearinghouse for the loan of this aid at no, or only a nominal, rental fee. Since a clearinghouse could also keep abreast of newly developed aids so the most appropriate and effective aids would be made available.The clearinghouse could keep track of requests for specific kinds of aids or assistance. These data would serve as the basis of directing developmental efforts for aids and instructional modifications that are non-existent

Evaluation/Assessment

■

One, research techniques that involve a small sample number must be refined and accepted by the science education research community.

■

Two, it is equally crucial that evaluation instruments that are both reliable and valid for use with handicapped students be developed.

The recommendations found in this category have greater significance than in any of the other categories in terms of long range accomplishments. In the absence of an organized body of knowledge relating to science education and the physically handicapped present decisions are now based on intuition, trial and error, and limited bits and pieces of knowledge. Thus, it becomes crucial that all the recommendations in this category be attended to in depth.

There are two pivotal problems in carrying out these recommendations. One, research techniques that involve a small sample number must be refined and accepted by the science education research community. Two, it is equally crucial that evaluation instruments that are both reliable and valid for use with handicapped students be developed.

Once solutions to these two problems are in hand then the intriguing problems of teaching science to these students can be fully investigated. For example, does a congenitially blind student internalize or structure science concepts in a way significantly different than a student who is not blind? Are there any effects on the cognitive growth of a quadriplegic who never manipulated objects but carefully observes others manipulate objects and verbally direct others to manipulate objects in a certain way? Are there identifiable teacher characteristics that enable certain science teachers to work effectively with a blind, deaf, or crippled student? And of utmost importance, what are the effects of alternative teaching strategies and instructional aids over a long period of time?

■

Longitudinal studies are essential and should be initiated immediately.

Longitudinal studies are essential and should be initiated immediately. A factor which may appear to be significant now in the education of handicapped students may not be significant, or may even be counterproductive, over a period of time.

Career Concerns

■

. . . handicapped students should have equal opportunities to pursue science related careers.

The recommendations on science careers and the handicapped are very clear from the NSTA conference. The recommendations all focus on one concern: handicapped students should have equal opportunities to pursue science related careers. It will be necessary for science educators to obtain assistance from many other groups if this goal is to be achieved. Counseling and guidance personnel, vocational rehabilitation officials and prospective employers will have to be active participants in this process. Everyone involved in the process of helping handicapped students make career decisions must recognize that being handicapped does not automatically mean the person can not be competent in the field of science.

Science teachers should be involved in career education programs in the schools that expose both handicapped and non-handicapped students to potential careers in science and related fields. This means up-to-date science career information must be available to science teachers.

While the general intention of the recommendations in this category is not debatable great care must be exercised in trying to achieve the intended goals. For example, in an effort to provide equal opportunities for handicapped students to pursue science related careers it is essential the existence of a handicapping condition should not be the sole factor in making career decisions. Career decisions should not be based on the fact the person is or is not handicapped. Such factors as the following should be considered when making career decisions: the aptitude of the person; the interests and desires of the person; and the immediate and long range prognosis of the handicapping condition. Handicapped students should be encouraged to make career decisions that are compatible with the parameters of their handicapping condition, personal interests and capabilities. Every attempt should be made to let these students make their own decisions on the basis of relevant and current information. Handicapped scientists might serve as a model to help some students reach a decision. Students should not be arbitrarily cut-off when they express an interest in a specific career. A blind student who develops aspirations of becoming a medical doctor or zoologist should not be told, "Forget it. A blind person can not become a medical doctor or zoologist." Blind persons have become medical doctors and zoologists, and more blind persons will do so in the future.

■

Handicapped students should be encouraged to make career decisions that are compatible with the parameters of their handicapping condition, personal interests and capabilities.

Educational Organizations and Agencies

The recommendations in the final category are directed mostly at the role of science education organizations in the education of handicapped students. There are several unique implications that emerge from these recommendations. One implication relates to the way in which science education organizations plan and conduct their professional meetings and conventions. Professional meetings and conventions should be barrier-free. This does not simply mean that the handicapped will be able to physically get into the buildings and move about the buildings. Rather it means much more. Handicapped persons should be able to fully participate in a meeting once they are there. This may mean having an interpreter for a deaf person; a braille program or schedule for a blind person; living accommodations appropriate for orthopedic handicapped persons (e.g., rooms in which a wheelchair will fit through a bathroom door); adequate transportation arrangements to the location of the meeting; and provisions to handle emergency situations. Handicapped people should be included in the planning and operation of barrier-free meetings.

■

Professional meetings and conventions should be barrier-free.

■

Handicapped people should be included in the planning and operation of barrier-free meetings.

Handicapped educators and scientists should be encouraged and invited to participate in professional meetings. Science education organizations should try to involve science educators who work in "special" schools for the deaf, blind, and orthopedic handicapped students. In the past there has been very little interaction between science educators in the "special" schools and the "regular" schools. Efforts to overcome this communication gap should be initiated.

Science education organizations should promote the teaching of science to physically handicapped in a variety of ways. They should seek to work with other professional education organizations, federal agencies, and community groups who work with youngsters. Science educators could help such community groups as the scouts, park and recreation organizations, and nature centers to plan science oriented activities that are accessible to physically handicapped youngsters. This kind of effort recognizes that science learning does not occur only in the science classroom in the school.

■

. . . science education organizations and agencies should take a leadership role in planning and implementing quality science education for physically handicapped students.

The recommendations in this category suggest that science education organizations and agencies should take a leadership role in planning and implementing quality science education for physically handicapped students. It is imperative that this occurs. But there are several different areas in which leadership roles should emerge. Some areas are: the preparation of science teachers to work with physically handicapped students; the collection and synthesis of research information on teaching science to physically handicapped students; the development of alternative teaching strategies and modifications of regular teaching strategies; the development and utilization of science career education materials for handicapped students; and systems by which science teachers can receive on-going support to plan and implement a program to provide quality science education to handicapped students.

Conclusion

This discussion has identified briefly a few implications that emerge from the recommendations presented in Chapter One. These recomendations do not represent an exhaustive examination of the problem to provide meaningful science education to physically handicapped students. However, an initial attempt has been made to identify potential solutions to the problem. Through this publication the concerns and views of parents, educators, handicapped persons and scientists are presented. Hopefully, by the end of this century there will be no need for a publication of this kind. By then we hope quality and appropriate science education will be available to all learners, regardless of their special learning needs.

Science Education and the Physically Handicapped: Implications for the future

Photo and Design Credits

Section 1	*Educational Facilities Laboratory*
2	*Marc Moshman*
3	*Dennis Schatz*
4	*Joe Jacobs*
5	*Marily DeWall*
6	*Thomas R. Post*
7	*Marc Moshman*
8	*Karen Littman*
9	*American Association for the Advancement of Science*
10	*Joe Jacobs*

National
Science
Teachers
Association

1742 Connecticut Avenue, N.W.
Washington, DC 20009

Stock No. 471-14760